## Review Assessment: Lec 02 Quiz

| Name: | Lec 02 Quiz |
| :--- | :--- |
| Status : | Completed |
| Score: | 20 out of 100 points |

## Instructions:

## Question 1

0 of 16 points
A projectile is launched from a cliff at a 42 degree angle above the horizontal. It eventually reaches the ground below. This question is exclusively about the projectile while it is in free fall. It is in free fall from the instant after it leaves the launcher until the instant before it hits the ground. Where, along the trajectory of the projectile, is the kinetic energy of the projectile at its minimum value?

Selected Answer: X Nowhere.
Correct Answer: $\checkmark$ At the highest point of its motion.
Feedback: Upon departure from the launcher the projectile has a fixed amount of mechanical energy. Part of that mechanical energy is potential energy and part is kinetic energy. Both change during the motion of the projectile but the total stays the same. The higher the projectile is, the greater its potential energy, and, in order for the total energy to remain unchanged, the lower its kinetic energy. At the top of its motion the projectile's potential energy is at its maximum value, thus, the kinetic energy of the projectile, at the top of its motion, must be at its minimum value.

## Question 2

16 of 16 points
A projectile is launched from a cliff at a 42 degree angle above the horizontal. It eventually reaches the ground below. This question is exclusively about the projectile while it is in free fall. It is in free fall from the instant after it leaves the launcher until the instant before it hits the ground. Where, along the trajectory of the projectile, is the kinetic energy of the projectile zero?

Selected Answer: $\downarrow$ Nowhere.
Correct Answer: $\downarrow$ Nowhere.
Feedback: Way to go.
The total mechanical energy of the projectile remains the same throughout its free fall. On the way up it gains potential energy as it loses kinetic energy. At the top of its trajectory, the projectile has no vertical component to its velocity but it is still moving downrange as fast as ever. At the top of its trajectory its potential energy is at its maximum value and its kinetic energy is at its minimum value but because it is still moving horizontally, the projectile still has some kinetic energy.

## Question 3

0 of 16 points
A projectile is launched from a cliff at a 42 degree angle above the horizontal. It eventually reaches the ground below. This question is exclusively about the projectile while it is in free fall. It is in free fall from the instant after it leaves the launcher until the instant before it hits the ground. Where, along the trajectory of the projectile, is the potential energy of the projectile at its maximum value?

Selected Answer: $\times$ Nowhere.
Correct Answer: $\checkmark$ At the highest point in its trajectory.
Feedback: The gravitational potential energy of an object near the surface of the earth can be expressed as mgh where $m$ is the mass of the object, $g$ is the earth's near-surface gravitational force constant $9.8 \mathrm{~N} / \mathrm{kg}$, and $h$ is the height of the object above a fixed, but arbitrarily chosen reference level. By inspection of this mathematical expression it is apparent that the greater the height of the object, the greater its gravitational potential energy. The height of the projectile is of course greatest when the projectile is
at the highest point in its motion. Thus the potential energy of the projectile is greatest at the highest point in its trajectory.

## Question 4

0 of 16 points
A projectile is launched from a cliff at a 42 degree angle above the horizontal. It eventually reaches the ground below. This question is exclusively about the projectile while it is in free fall. It is in free fall from the instant after it leaves the launcher until the instant before it hits the ground. Where, along the trajectory of the projectile, is the kinetic energy of the projectile at its maximum value?

## Selected Answer: $\times$ Nowhere.

Correct Answer: $\checkmark$ At the lowest point in its motion, its location immediately prior to hitting the ground.
Feedback: The projectile starts out with a fixed amount of mechanical energy, partly in the form of gravitational potential energy and partly in the form of kinetic energy. It has that same fixed amount of mechanical energy throughout the motion. On the way up, the projectile gains potential energy at the same rate that it loses kinetic energy. On the way down it loses potential energy at the same rate that it gains kinetic energy. Once it gets back down to its launch level it has the same kinetic energy as it had upon being launched and the same potential energy as it had upon being launched. As it continues to fall toward the ground it continually gains kinetic energy and loses potential energy so that at its lowest possible free-fall position, the projectile has the most kinetic energy that it has throughout its free fall.

## Question 5

0 of 16 points
Consider a pendulum consisting of a metal ball on the end of a slender string. A person pulls the ball to one side, keeping the string taught. The ball moves along an arc, increasing its height above the ground as it is moved to one side. Consider the reference level for potential energy of the ball to be the ball's lowest possible level. The ball is released from rest. At it's release point it has 15 joules of potential energy. The ball swings back and forth. Ignore air resistance and friction. What is the kinetic energy of the ball when it is at its lowest position?


Selected Answer: $\times 0$ joules
Correct Answer: $\checkmark 15$ joules
Feedback: The total mechanical energy of the of the ball, the sum of its gravitational potential energy and its kinetic energy, remains the same throughout the motion of the ball. It starts out with 0 J of kinetic energy and 15 J of potential energy for a total of 15 J of mechanical energy. Thus it always has 15 J of mechanical energy. At the bottom of its motion it has 0 J of potential energy so it must have 15 J of kinetic energy in order for it to have a total of 15 J of mechanical energy.

## Question 6

## 4 of $\mathbf{2 0}$ points

A 1 kg object hangs from the end of a very long string of negligible mass. A person pulls the object to one side, keeping the string taut, to the point where the mass is 1 meter higher than its hanging position. Considering the hanging position to be the zero of gravitational potential energy, the object has 9.8 joules of potential energy in this raised position. The person releases the object from rest, at its raised position. The object begins swinging back and forth. Neglect air resistance as you match answer items to the question items below. Each answer item may be used more than once.

## Question



Where, in the motion of the object, is its potential energy a maximum?

Where in the motion of the object is its potential energy a minimum?

Where, in the motion of the object, is its kinetic energy a

## Correct Match

$\checkmark$ D. At the top of its motion. That is, at the release point and at the highest point of its swing away from the release point.
$\checkmark$ C. At the very bottom of its motion.
$\checkmark$ C. At the very bottom of its motion.

## Selected Match

$X A$. It has the same value everywhere so it has its maximum value everywhere.
$X A$. It has the same value everywhere so it has its maximum value everywhere.
$X A$. It has the same value everywhere so it has its
maximum value everywhere.

Where in the motion of the object is its kinetic energy a minimum?
$\checkmark$ D. At the top of its motion. That is, at the release point and at the highest point of its swing away from the release point.
$X A$. It has the same value everywhere so it has its maximum value everywhere.

Where in the motion of the object is the total mechanical energy of the object a maximum?
$\checkmark$ A. It has the same value everywhere so it has its maximum value everywhere.
$\checkmark$ A. It has the same value everywhere so it has its maximum value everywhere.

Feedback: The total mechanical energy, of the of the object, the sum of its gravitational potential energy and its kinetic energy, remains the same throughout the motion of the object. It starts out with 0 J of kinetic energy and 9.8 J of potential energy for a total of 9.8 J of mechanical energy. The gravitational potential energy of an object is directly proportional to its elevation. Hence, the lower the object is, the smaller its potential energy is, and, (in order for the total energy of the object to remain constant) the greater its kinetic energy is.

## Review Assessment: Lec 03 Quiz

| Name: | Lec 03 Quiz |
| :--- | :--- |
| Status : | Completed |
| Score: | 24 out of 100 points |

## Instructions:

## Question 1

## 0 of 20 points

In the expression $1 / 2 k x^{2}$ for the potential energy stored in the spring, what does the x represent?

Selected Answer: $\times$ The length of the spring.
Correct Answer: $\checkmark$ The amount by which the spring is stretched or compressed.
Feedback: Quite often, we consider there to be an object at one end of the spring while the other end of the spring is fixed in position (e.g. by being attached to a wall). x is the position of the object measured with respect to its equilibrium position. The value of x represents a position on an x -axis which is collinear with the spring and whose origin is at the equilibrium position. The equilibrium position is the position of the object for which the spring is neither stretched nor compressed.

The positive direction for the x -axis is typically chosen to be the direction in which one has to move the object from its equilibrium position in order to stretch the spring. In that case, $x$ is the amount by which the spring is stretched (where a negative amount of stretch means the spring is actually compressed).

It is acceptable to define the $x$-axis such that the positive direction is the direction in which one has to move the object from its equilibrium position in order to compress the spring. In that case, x is the amount by which the spring is compressed (where a negative amount of compression means the spring is actually stretched).

Match the units to the physical quantity that is measured in those units.

| Question | Correct Match | Selected Match |
| :--- | :--- | :--- |
| kg | $\checkmark$ D. mass | $\times$ A. time |
| J | $\checkmark$ C. energy | $\times$ A. time |
| m | $\checkmark$ E. distance | $\times$ A. time |
| $\mathrm{m} / \mathrm{s}$ | $\checkmark$ B. velocity | $\times$ A. time |
| s | $\checkmark$ A. time | $\checkmark$ A. time |

Feedback: The main purpose of this question is to familiarize you with the jargon "physical quantity". It is important to recognize that there is a distinction between a physical quantity and the units in which that physical quantity is measured.

A block of mass $m$, on a flat horizontal frictionless surface, is pushed up against the end of a horizontal spring, the other end of which is connected to a wall, so that it compresses the spring by an amount $x$. The force constant of the spring is $k$. Consider the mass of the spring to be negligible. The block is released, and the spring pushes the block away from the wall. What is the kinetic energy of the block after it loses contact with the spring? (Hint: From the wording of the question you are supposed to know that $\mathrm{m}, \mathrm{k}$, and x are to be considered known quantities, and, that your answer should have only known quantities in it.)

Selected Answer: $\times 0 \mathrm{mgh}$
Correct Answer: $\quad 1 / 2 k x^{2}$
Feedback: We start with a spring sticking out of a wall. The spring extends horizontally over a flat, horizontal frictionless surface. Now someone pushes a block up against the end of the spring. The person pushes the block directly toward the wall compressing the spring. Energy is stored in the spring as it is compressed. Then the person releases the block. It is at this instant, the instant that the person is out of the picture, that we can begin applying conservation of energy. At that instant, before the spring has had time to start expanding, the spring is compressed the known amount $x$ and the block is at rest. That is the instant to be characterized by the Before Picture.


In the after picture, the block is free of the spring. We can solve for the kinetic energy $K$ ' in the after picture by setting the total mechanical energy in the before picture equal to the total mechanical energy in the after picture:

$$
\begin{aligned}
E & =E^{\prime} \\
K+U & =K^{\prime}+U^{\prime} \\
0+\frac{1}{2} k x^{2} & =K^{\prime}+0 \\
K^{\prime} & =\frac{1}{2} k x^{2}
\end{aligned}
$$

Note how important it is to write a lower case $k$ (spring constant) that is distinguishable from an upper case $K$ (kinetic energy).

Which has more rotational kinetic energy, an object with a rotational inertia of $4 \mathrm{~kg} \cdot \mathrm{~m}^{2}$ and an angular velocity of $8 \mathrm{rad} / \mathrm{s}$, or, an object with a rotational inertia of $8 \mathrm{~kg} \cdot \mathrm{~m}^{2}$ and an angular velocity of $4 \mathrm{rad} / \mathrm{s}$ ?

Selected Answer: $\checkmark$ An object with a rotational inertia of $4 \mathrm{~kg} \cdot \mathrm{~m}^{2}$ and an angular velocity of $8 \mathrm{rad} / \mathrm{s}$.
Correct Answer: $\checkmark$ An object with a rotational inertia of $4 \mathrm{~kg} \cdot \mathrm{~m}^{2}$ and an angular velocity of $8 \mathrm{rad} / \mathrm{s}$.
Feedback: Nice work!

$$
\begin{array}{ll}
I_{1}=4 \mathrm{~kg} \cdot \mathrm{~m}^{2} & I_{2}=8 \mathrm{~kg} \cdot \mathrm{~m}^{2} \\
\omega_{1}=8 \frac{\mathrm{rad}}{\mathrm{~s}} & \omega_{2}=4 \frac{\mathrm{rad}}{\mathrm{~s}} \\
K_{1}=\frac{1}{2} I_{1} \omega_{1}^{2} & K_{2}=\frac{1}{2} I_{2} \omega_{2}^{2} \\
K_{1}=\frac{1}{2}\left(4 \mathrm{~kg} \cdot \mathrm{~m}^{2}\right)\left(8 \frac{\mathrm{rad}}{\mathrm{~s}}\right)^{2} & K_{2}=\frac{1}{2}\left(8 \mathrm{~kg} \cdot \mathrm{~m}^{2}\right)\left(4 \frac{\mathrm{rad}}{\mathrm{~s}}\right)^{2} \\
K_{1}=128 \mathrm{~J} & K_{2}=64 \mathrm{~J}
\end{array}
$$

## Question 5

0 of $\mathbf{2 0}$ points
A disk lies horizontally on a massless, frictionless, rotational motion support such that the disk is spinning freely about a vertical axis through the center of the disk and perpendicular to the face of the disk. A second disk, identical to the first disk is held in place a negligible height (immeasurably close but not touching) above the first disk. The second disk is aligned so perfectly with the first disk that the axis of rotation of the first disk also passes through the center of the second disk. The person holding the second disk drops it onto the first disk and the two disks spin as
one. Is mechanical energy conserved in this process?

Selected Answer: $\times$ Yes
Correct Answer: $\checkmark$ No
Feedback: Make sure that you don't justify the correct answer (no) on the basis of gravitational energy mgh. We are told that the initial height of the dropped disk is negligible, so, we must neglect it in our considerations. That means nothing undergoes a non-negligible elevation change in the process, so, gravitational potential energy is not relevant here.

The new spin rate is clearly less than the original spin rate of the one disk in that two disks spinning together at the original spin rate would have twice as much kinetic energy as the one disk spinning at that rate and the kinetic energy of the system is certainly not going to increase. So the first disk, let's call it disk $A$, slows down and the second disk, let's call it disk $B$, speeds up (from 0 rad/s) upon being dropped onto disk $A$.

The correct answer (no) is easy to arrive at in a case where the two disks are made, for instance, out of concrete and one can observe that when $B$ is dropped on $A$, the top surface of $A$ slides against the bottom surface of $B$ while $B$ speeds up and $A$ slows down until they are both spinning at the same rate. Sliding friction is what causes the two disks to eventually spin with the same angular velocity and we know that energy is converted from mechanical energy to thermal energy when sliding friction takes place so mechanical energy is not conserved.

But suppose disk $A$ is spinning slowly enough that sliding is not apparent. Suppose we do the experiment and it looks like $B$ locks immediately onto $A$ in such a manner that there is no obvious conversion of mechanical energy into thermal energy. By observation of the interaction, there may or may not be some such energy conversion. To determine whether mechanical energy is conserved in such a case, we turn to an idealized version of the experiment in which it is easier to keep track of the energy. Suppose the top surface of A was completely frictionless but we had an ideal, massless, springs-and-tabs arrangement on the disks as shown in the diagram below (in which our view of the spring on the back side of $A$ is blocked).

$B$ is dropped (from a negligible height) onto the frictionless surface of A. A continues to rotate a fraction of a turn, as if nothing had happened, until the springs on A run into the tabs on B. The "collision", gets B spinning ever faster in the same direction of $A$ and slows $A$ down, while compressing the springs, until at one instant, $A$ and $B$ are spinning at the same rate. At that instant, the disks are spinning as one with a single velocity just as in the case of two plain disks with friction. (As time goes by after that, the spring will decompress speeding up $B$ even more and slowing A even more but we focus our attention on that instant when the spring is maximally compressed and the disks have one and the same angular velocity). The pair-of-disks with the springs and tabs, at that instant, will have the same kinetic energy as the pair-of-disks with friction. In the case of the disks with the springs and tabs, however, there is also potential energy stored in the springs. There is no such additional mechanical energy in the case of the plain disks with friction. As such, that amount of mechanical energy that would be stored in the springs in the idealized case, must have been lost (converted to other forms such as thermal energy and permanent deformation) in the actual case involving two plain disks with friction. Mechanical energy is not conserved whether sliding is apparent or not.

## Review Assessment: Lec 04 Quiz

Name: Lec 04 Quiz

Status: Completed
Score: 0 out of 100 points

## Instructions:

## Question 1

Consider a bowling ball and a Ping Pong ball, each moving along a straight line path at constant velocity. Which has the greater magnitude of momentum?

Selected Answer: $\times$ Neither, they both have the same momentum.
Correct Answer: $\checkmark$ Insufficient information is given to determine a definite answer.
Feedback: One needs to know the speed of each. Given the objects, the bowling ball clearly has much more mass. But momentum depends on both mass and velocity. Suppose the bowling ball's mass is 1000 times that of the Ping Pong ball. If the speed of the Ping Pong ball is less than 1000 times the speed of the bowling ball, then the magnitude of the bowling ball's momentum is greater. But if the speed of the Ping Pong ball is greater than 1000 times the speed of the bowling ball, then the magnitude of the Ping Pong ball's momentum is greater.

Question 2

## 0 of 20 points

Consider two cars, both moving eastward along a straight road. Car 1 is in front of car 2. Car 1 has a mass of 1200 kg and a speed of $24 \mathrm{~m} / \mathrm{s}$. Car 2 has a mass of 1100 kg and a speed of $32 \mathrm{~m} / \mathrm{s}$. Consider eastward to be the positive direction. Car 2 collides with car 1 . The two cars stick together and move off as one object. No external eastward/westward forces act on either car. What is the total momentum of the combination object, consisting of the two cars stuck together, after the collision?

Selected Answer: X Zero
Correct Answer: $\quad$ 64,000 kg•m/s
Feedback:


Consider two cars, both moving eastward along a straight road. Car 1 is in front of car 2 . Car 1 has a mass of 1200 kg and a speed of $24 \mathrm{~m} / \mathrm{s}$. Car 2 has a mass of 1100 kg and a speed of $32 \mathrm{~m} / \mathrm{s}$. Consider eastward to be the positive direction. Car 2 collides with car 1. The two cars stick together and move off as one object. No external eastward/westward forces act on either car. What is the mass of the combination object consisting of the two cars stuck together?

Selected Answer: × 100 kg
Correct Answer: $\checkmark$ No other answer provided is correct.

## Feedback:



## Question 4

Consider two cars, both moving eastward along a straight road. Car 1 is in front of car 2. Car 1 has a mass of 1200 kg and a speed of $24 \mathrm{~m} / \mathrm{s}$. Car 2 has a mass of 1100 kg and a speed of $32 \mathrm{~m} / \mathrm{s}$. Consider eastward to be the positive direction. Car 2 collides with car 1 . The two cars stick together and move off as one object. No external eastward/westward forces act on either car. What is the total momentum of the system of cars prior to the collision?

Selected Answer: $\times$ Zero
Correct Answer: $\checkmark 64,000 \mathrm{~kg} \cdot \mathrm{~m} / \mathrm{s}$
Feedback: The total momentum is the sum of the momentum of car 1 and the momentum of car 2. Calculate each momentum individually and then add them together.


Question 5
0 of $\mathbf{2 0}$ points
Consider two cars, both moving eastward along a straight road. Car 1 is in front of car 2 . Car 1 has a mass of 1200 kg and a speed of $24 \mathrm{~m} / \mathrm{s}$. Car 2 has a mass of 1100 kg and a speed of $32 \mathrm{~m} / \mathrm{s}$. Consider eastward to be the positive direction. Car 2 collides with car 1. The two cars stick together and move off as one object. No external eastward/westward forces act on either car. What is the velocity of the combination object, consisting of the two cars stuck together, after the collision?

Selected Answer: X Zero
Correct Answer: $\checkmark 28 \mathrm{~m} / \mathrm{s}$
Feedback:

BEFORE:

$m_{2}=1100 \mathrm{~kg}$


$$
m_{1}=1200 \mathrm{~kg}
$$

$$
p=p_{1}+p_{2}
$$

$$
=m_{1} v_{1}+m_{2} v_{2}
$$

$$
=1200 \mathrm{~kg}(24 \mathrm{~m} / \mathrm{s})+1100 \mathrm{~kg}(32 \mathrm{rg} / \mathrm{s})
$$

$$
p=64,000 \mathrm{~kg} \cdot \mathrm{~m} / \mathrm{s}
$$

AFTER:

$m=2300 \mathrm{~kg}$
$p^{\prime}=p$
$P^{\prime}=64,000 \mathrm{~kg} \cdot \frac{\mathrm{~m}}{\mathrm{~s}}$

$$
\begin{aligned}
p^{\prime} & =m V \\
V & =\frac{p^{\prime}}{m} \\
V & =\frac{64,000 \mathrm{~kg} \frac{\mathrm{~m}}{\mathrm{~s}}}{2300 \mathrm{~kg}}=27.8 \frac{\mathrm{~m}}{\mathrm{~s}} \\
V & =28 \frac{\mathrm{~m}}{\mathrm{~s}}
\end{aligned}
$$

## Review Assessment: Lec 05 Quiz

| Name: | Lec 05 Quiz |
| :--- | :--- |
| Status : | Completed |
| Score: | 40 out of 100 points |

## Instructions:

## Question 1

Some people are on a playground merry-go-round which is spinning freely. Consider the merry-go-round-plus-people to be the "object" whose rotational motion is under consideration. All at once, the people move to the center of the merry-go-round. What happens to the mass of the merry-go-round-plus-people?

Selected Answer: $\checkmark$ It stays the same.
Correct Answer: $\downarrow$ It stays the same.
Feedback: Well done.

## Question 2

0 of 20 points
Some people are on a playground merry-go-round which is spinning freely. Consider the MERRY-GO-ROUND to be the "object" whose rotational motion is under consideration. All at once, the people move to the center of the merry-go-round. What happens to the angular momentum of the MERRY-GO-ROUND?

Selected Answer: $\times$ It stays the same.
Correct Answer: $\downarrow$ It increases.
Feedback: Considering the object to be the merry-go-round-plus-people, we know that the object spins faster because when the people move in they decrease the moment of inertia and to keep the angular momentum of the total object the same the angular velocity must increase.

Now consider the merry-go-round alone to be the object under study. The previous considerations lead us to the correct conclusion that its angular velocity increases. But, its moment of inertia does not change. It is a solid rigid body. There is no redistribution of its mass. The angular momentum of the merry-go-round is the product of its moment of inertia and its angular velocity. If its angular velocity increases with no change in its moment of inertia then the angular momentum of the merry-go-round must increase.

But how could this be? Shouldn't angular momentum be conserved? According to the law of conservation of angular momentum, if there is no external torque action on an object, its angular momentum does not change. Ah, but in this case there is an external torque. In this case, the people are not part of the object. They are part of its surroundings. When they climb into the center they must exert torque on the merry-go-round itself. That is what speeds it up.

Some people are on a playground merry-go-round which is spinning freely. Consider the merry-go-round-plus-people to be the "object" whose rotational motion is under consideration. All at once, the people move to the center of the merry-go-round. What happens to the angular momentum of the merry-go-round-plus-people?

Selected Answer: $\downarrow$ It stays the same.
Correct Answer: $\checkmark$ It stays the same.
Feedback: Way to go!
According to the law of the conservation of angular momentum, as long as there are no external torques acting on the object (the merry-go-round-plus-people in this case), the angular momentum of
the object does not change. In the case at hand, there are no external torques acting on the object so its angular momentum does not change.

## Question 4

0 of 20 points
Some people are on a playground merry-go-round which is spinning freely. Consider the merry-go-round-plus-people to be the "object" whose rotational motion is under consideration. All at once, the people move to the center of the merry-go-round. What happens to the angular velocity of the merry-go-round-plus-people?

Selected Answer: $\times$ It stays the same.
Correct Answer: $\checkmark$ It increases.
Feedback: The moment of inertia of the object decreases but the angular momentum stays the same. The angular momentum is the product of the moment of inertia and the angular velocity:
$L=I \omega$
The only way the angular momentum can stay the same when the moment of inertia I decreases is for the angular velocity $\omega$ to increase.

## Question 5

0 of $\mathbf{2 0}$ points
Some people are on a playground merry-go-round which is spinning freely. Consider the merry-go-round-plus-people to be the "object" whose rotational motion is under consideration. All at once, the people move to the center of the merry-go-round. What happens to the rotational inertia of the merry-go-round-plus-people?

Selected Answer: $\times$ It stays the same.
Correct Answer: $\checkmark$ It decreases.
Feedback: The rotational inertia depends not only on the mass of the object (the merry-go-round-plus-people in this case) but how that mass is distributed. The farther the mass is, on the average, from the axis of rotation, the greater the rotational inertia. When the people rush toward the center of the merry-goround they make it so that the mass of the merry-go-round-plus-people is, on the average, closer to the axis of rotation. Hence, the moment of inertia of the merry-go-round-plus-people decreases.

## Review Assessment: Lec 06 Quiz

Name: Lec 06 Quiz
Status: Completed
Score: 0 out of 100 points

## Instructions:

## Question 1

0 of $\mathbf{2 0}$ points
Consider an object undergoing linear motion. Define the forward direction to be the positive direction. In which case or cases is the acceleration of the object negative? (Indicate all the correct answers.)

Selected Answers: $\times$ The object is going forward and speeding up.

Correct Answers: $\checkmark$ The object is going forward and slowing down.
$\checkmark$ The object is going backward and speeding up.

Feedback: If the object is speeding up, then the acceleration is in the same direction as the direction in which the object is going. So if the object is going forward and speeding up, the acceleration is forward (positive). But, if the object is going backward and speeding up, the acceleration is backward (negative).

If the object is slowing down then its acceleration is in the direction opposite to the direction in which it is going. So, if it is going forward and slowing down, its acceleration is backward (negative). But, if it is going backward and slowing down, its acceleration is forward (positive).

A person walks along a straight line path. The person's position $x$ is measured with respect to a start line. During a particular time interval, the person is observed to go from $x=2$ meters to $x=6$ meters and from there to $x=3$ meters. What is the displacement of the person in the time interval in question?

Selected Answer: X 2 meters
Correct Answer: $\checkmark$ No other answer provided is correct.
Feedback: The displacement (change in position) is the final position minus the initial position.

## Question 3

0 of 20 points
A person walks along a straight line path. The person's position x is measured with respect to a start line. During a particular time interval, the person is observed to go from $x=2$ meters to $x=6$ meters and from there to $x=3$ meters. What is the person's total distance traveled in the time interval in question?

Selected Answer: $\times 1$ meter
Correct Answer: $\checkmark 7$ meters
Feedback: The person travels 4 meters in going from $x=2$ meters to $x=6$ meters and an additional 3 meters in going (backwards) from $x=6$ meters to $x=3$ meters. Unlike displacements, all contributions to the total distance traveled are positive regardless of the direction in which the person is going.

## Question 4

0 of 20 points
What is the acceleration of an object that is constrained to move along a straight line path? (Choose the one best answer.)

Selected Answer: $\times$ How fast and which way the velocity of an object is going.
Correct Answer: $\checkmark$ The rate of change and the direction of change of the object's velocity.
Feedback: "How fast and which way the velocity of an object is going" is nonsense. Velocity doesn't "go". Objects go.
"How fast the speed of an object is changing" is just the magnitude of acceleration. Acceleration has direction. Just as speed is not velocity, magnitude of acceleration is not acceleration.
"How fast and which way the object is going" is velocity. Not acceleration.
"The rate of change and the direction of change of the object's velocity" is correct. The acceleration of an object is how fast and which way the velocity of that object is changing.

Question 5
0 of $\mathbf{2 0}$ points
What is the difference, if any, between speed and velocity? (Choose the one best answer.)

Selected $\quad \times$ There is no difference. They both characterize how fast something is going.
Answer:
Correct $\quad \checkmark$ Velocity characterizes both how fast and which way something is going, whereas speed just Answer: characterizes how fast it is going.

Feedback: The speed of an object is the magnitude of its velocity. Velocity has both magnitude and direction.

## Review Assessment: Lec 07 Quiz

Name: Lec 07 Quiz

Status: Completed
Score: 0 out of 100 points

## Instructions:

## Question 1

## 0 of 50 points

Would it be correct to apply one or more of the constant acceleration equations in solving the following problem?

At the top of a hill of height 135 meters, a skier already has a forward velocity of $2.00 \mathrm{~m} / \mathrm{s}$. The skier continues forward, down the hill depicted below. How fast is the skier going at the bottom of the hill? Consider the snow to be frictionless and assume the skier does not use ski poles on the way down. Ignore wind and air resistance.

Note that you are not supposed to solve the problem. You are just supposed to answer the question as to whether or not it would be correct to apply one or more of the constant acceleration equations in solving the problem.


Selected Answer: $\times$ Yes
Correct Answer: $\checkmark$ No
Feedback: Both the direction and the magnitude of the skier's acceleration vary on the way down the hill. The acceleration is definitely not constant so it would be incorrect to use the constant acceleration equations.

## Question 2

0 of 50 points
Do the constant acceleration equations apply in the case of the following problem?

A car is initially at rest. The motor is running. Starting at time 0 the driver releases the brake and slowly begins depressing the gas pedal farther and farther as time goes by, until, after 5.0 seconds, the gas pedal is pressed all the way down to the floor. Assume that the driver keeps the car headed and going in a straight line path for the entire 5.0 seconds. Assume that the acceleration increases steadily during the five-second time interval in question such that, at the five-second mark, the acceleration is 6.0 mph per second. How far does the car travel during the first 5.0 seconds of its motion?

Note that you are not supposed to solve the problem. You are just supposed to indicate whether or not the constant acceleration equations apply to the problem.

Selected Answer: $\times$ Yes
Correct Answer: $\checkmark$ No
Feedback: The acceleration is not constant. The acceleration increases from 0 to $6.0 \mathrm{mph} / \mathrm{s}$. The constant
acceleration equations, as the name applies, are good for cases in which the acceleration is constant.

## Review Assessment: Lec 08 Quiz

Name: Lec 08 Quiz
Status : Completed
Score: 20 out of 100 points

## Instructions:

## Question 1

In solving a "Collision Type II" problem, it is important to:

Selected $\times$ use the correct mass for each of the objects.
Answer:
Correct $\quad \checkmark$ Use the same start line and the same positive direction in establishing the value of, or an Answer: expression for, the position of each object.

## Question 2

0 of $\mathbf{2 0}$ points
In the type II collision, what is the one physical quantity that always has the same value for both objects involved in the so-called collision?

Selected Answer: $\times$ position
Correct Answer: $\checkmark$ time

## Question 3

0 of 20 points
The "Collision Type I" problem was studied as part of the lecture on the Conservation of Momentum. It involved one object crashing into another one. The "Collision Type II" problem...

Selected $\times$ also involves one object crashing into another, but, the two objects bounce off of each other Answer: with no loss of mechanical energy.

Correct $\quad \checkmark$ does not necessarily involve an actual crash, rather, it involves two objects, each traveling along Answer: a straight line path. The so-called "collision" occurs when the two objects have one and the same position.

## Question 4

20 of 20 points
Assume one chooses to use the subscript 1 for each variable used to characterize one of the objects involved in a type II collision and the subscript 2 for each variable used to characterize the other object. What then is the equation corresponding to the fact that the two objects experience a "type II collision?"


Selected Answer: $\checkmark \mathrm{x}_{1}=\mathrm{x}_{2}$
Correct Answer: $\quad$, $\mathrm{x}_{1}=\mathrm{x}_{2}$
Feedback: Nice work!

## Question 5

0 of 20 points
We have defined the Collision Type II equation to be $x_{1}=x_{2}$ where $x_{1}$ is the position of object 1 and $x_{2}$ is the position of object 2 . In order for this equation to apply in the case of the following problem which of the following combinations of starting position ( $\mathrm{x}=0$ ) and positive direction would be appropriate? Indicate all that are correct.

Car 1 is traveling along a straight line. Car 2 is traveling along another straight line, parallel to, and
rather close to (so close that the cars will be only a few centimeters apart when they are side-by-side) the line along which car 1 is traveling. At time zero the cars are 782 m apart. At time zero, car 1 is moving toward car 2 with a speed of $15 \mathrm{~m} / \mathrm{s}$ relative to the road and an acceleration of $2.5 \mathrm{~m} / \mathrm{s}^{2}$ relative to the road. At time zero car 2 is moving toward car 1 with a speed of $28 \mathrm{~m} / \mathrm{s}$ relative to the road and an acceleration of $2.9 \mathrm{~m} / \mathrm{s}^{2}$ relative to the road. How far must car 2 travel in order to be side-by-side with car 1 ?

Note that you are not supposed to solve the problem. Just indicate which of the following would be an appropriate combination of start line $(x=0)$ and positive direction. Indicate the answer, or all the answers, that are correct.

Selected $\quad \checkmark$ Define $x$ to be 0 at the initial position of car 1 and the positive direction to be the direction of Answers: motion of car 1.

Correct $\quad \checkmark$ Define x to be 0 at the initial position of car 1 and the positive direction to be the direction of Answers: motion of car 1.
$\checkmark$ Define $x$ to be 0 at the initial position of car 1 and the positive direction to be the direction of motion of car 2.
$\checkmark$ Define $x$ to be 0 at the initial position of car 2 and the positive direction to be the direction of motion of car 1.
$\checkmark$ Define $x$ to be 0 at the initial position of car 2 and the positive direction to be the direction of motion of car 2.

Feedback: Any one starting position can be defined to be the start line ( $\mathrm{x}=0$ ) and either of the two directions can be chosen as the positive direction. As long as one uses one and the same starting position for both cars and one and the same positive direction for both cars the Collision Type II equation $\mathrm{x}_{1}=\mathrm{x}_{2}$ applies.

## Review Assessment: Lec 09 Quiz

Name: Lec 09 Quiz
Status: Completed
Score: 20 out of 100 points

## Instructions:

Question 1

## 0 of 20 points

For each graph characteristic, indicate the corresponding physical quantity used to characterize linear motion involving constant acceleration, or, if none of the physical quantities, applies, indicate "none".

| Question | Correct Match | Selected Match |
| :--- | :--- | :--- |
| The slope of the position versus time curve. | $\checkmark \mathrm{C}$. Velocity | $\times \mathrm{A}$. Time |

## Question 2

A start line $(x=0)$ and a positive $x$-direction are established for a straight road. Observations are made on the motion of a car on that road. The observer has a stopwatch in hand. The time in the graph below represents the stopwatch reading. The stopwatch was started at time 0 . Based on the graph below, for each time interval specified, indicate the appropriate description of the motion of the car during the time interval.


## Question

zero to five seconds

## Correct Match

$\checkmark$ F. At the start of the time interval the car is already moving forward. It continues to move forward but is steadily slowing down.

## Selected Match

$\times \mathrm{A}$. Beginning at rest the car remains at rest throughout the time interval.
ten seconds the time interval.
ten seconds to $\quad \checkmark$ C. Beginning at rest the car speeds up steadily in the twenty seconds backward direction.
remains at rest throughout the time interval.
$\times \mathrm{A}$. Beginning at rest the car remains at rest throughout the time interval.

## Question 3

0 of 20 points
A car moves on a straight line path, starting from rest at time 0 . It undergoes a constant acceleration of $5 \mathrm{~m} / \mathrm{s}^{2}$ for 5 seconds. Then the car experiences no acceleration for 10 seconds at which point it begins to accelerate steadily at $-5 \mathrm{~m} / \mathrm{s}^{2}$ and continues to do for the final 5 seconds of motion under study. Which graph of acceleration vs. time correctly characterizes the motion of the car?

Selected Answer: $\times$


Correct Answer: $\checkmark$


A car moves on a straight line path, starting from rest, at $x=0$, at time 0 . It undergoes a constant acceleration of
$5 \mathrm{~m} / \mathrm{s}^{2}$ for 5 seconds. Then the car experiences no acceleration for 10 seconds at which point it begins to accelerate steadily at $-5 \mathrm{~m} / \mathrm{s}^{2}$ and continues to do for the final 5 seconds of motion under study. Which graph of position vs. time correctly characterizes the motion of the car?

Selected Answer: X


Correct Answer:


Feedback: We are told the car is at $x=0$ at time 0 so our Position vs. Time curve starts at the origin. The slope of the Position vs. Time curve is the velocity. Since the car has zero velocity at time 0 , the Position vs. Time curve must be horizontal at $t=0$. During the first 5 seconds, the velocity of the car is increasing (positive acceleration given), thus, the slope of the curve must be increasing, so, it is "curved up" for the first 5 seconds.

For the next 10 seconds, the velocity is constant at whatever value it had at $\mathrm{t}=5 \mathrm{~s}$. So, the slope is constant, meaning the "curve" is a straight line from $t=5 \mathrm{~s}$ to $\mathrm{t}=15 \mathrm{~s}$. Because the velocity during this entire interval is the same as what it was at $t=5 \mathrm{~s}$, the line must join smoothly to the $\mathrm{t}=0 \mathrm{~s}$ to $\mathrm{t}=5 \mathrm{~s}$ curve. (No kink!)

During the last 5 seconds, the car slows down. Since its velocity is decreasing, this means that the slope of the Position vs. Time curve is decreasing. But the car is still getting farther from the start line so the position is still increasing. Hence the curve "goes up" but is "curved down." There is no abrupt
change in velocity at $t=15 \mathrm{~s}$ so there can be no abrupt change in the slope. This means that the curve characterizing the last 5 s of the motion of the car must join smoothly to the line characterizing the motion of the car from $\mathrm{t}=5 \mathrm{~s}$ to $\mathrm{t}=15 \mathrm{~s}$. (No kink!)

A start line ( $\mathrm{x}=0$ ) and a positive x -direction are established for a straight road. Observations are made on the motion of a car on that road. The observer has a stopwatch in hand. The time in the graph below represents the stopwatch reading. The stopwatch was started at time 0 . Based on the graph below, characterize the initial (time zero) position and velocity of the car.


Selected $\quad \times$ The car is at rest at the start line.
Answer:
Correct $\quad \checkmark$ The car is at the start line but it already has an appreciable forward speed. The observer must Answer: have started the stopwatch when the car was already moving, just as it crossed the start line.

Feedback: You can tell that the car is at the start line at time 0 because the curve passes through the origin. You can tell that the velocity is positive at time 0 because the curve has a positive slope at the origin (and the velocity is the slope of the x vs. t curve).

A car moves on a straight line path, starting from rest at time 0 . It undergoes a constant acceleration of $5 \mathrm{~m} / \mathrm{s}^{2}$ for 5 seconds. Then the car experiences no acceleration for 10 seconds at which point it begins to accelerate steadily at $-5 \mathrm{~m} / \mathrm{s}^{2}$ which it continues to do for the final 5 seconds of motion under study. Which graph of velocity vs. time correctly characterizes the motion of the car?

Selected Answer:


Correct Answer:


Feedback: Nice work!
For each time interval, the acceleration is constant. Since the acceleration is the slope of the velocity vs. time curve, this means that for each of the three 5-second time intervals the graph of velocity vs. time must be a straight line segment. (A "curve" with a constant slope is a straight line.) The accelerations, and hence the slopes for the three time intervals are positive, zero, and negative respectively. That means the three line segments must slope upward, be horizontal, and slope downward, respectively.

## Review Assessment: Lec 10 Quiz

Name: Lec 10 Quiz

Status: Completed
Score: 0 out of 100 points

## Instructions:

Question 1

## 0 of 100 points

The positions of a particle moving on a frictionless horizontal surface are specified by means of a Cartesian coordinate system. At time 0 , the particle is at ( $0,10.0 \mathrm{~m}$ ) and has a velocity of $12.8 \mathrm{~m} / \mathrm{s}$ at $128.66^{\circ}$. The particle has a constant acceleration of $2.00 \mathrm{~m} / \mathrm{s}^{2}$ at $0.0^{\circ}$. Which of the following diagrams best characterizes the trajectory of the particle?

Selected Answer: $\times$


Correct Answer:


Feedback: For purposes of discussion I am going to call the positive x direction rightward and the positive y direction upward, the way they look on the graph when it is viewed on your screen. Based on the given initial velocity, the object starts out headed up and to the left. The Cartesian component vectors of the initial velocity vector are in the -x direction and the $+y$ direction respectively. The $y$ component of the velocity never changes because there is no acceleration in the $y$ direction. There is, however, an acceleration in the $+x$ direction. $T$

## Review Assessment: Lec 11 Quiz

Name: Lec 11 Quiz

## Status: Completed

Score: 20 out of 100 points

## Instructions:

Question 1

## 0 of 20 points

A marble is rolling northeast at $.65 \mathrm{~m} / \mathrm{s}$ with respect to the railroad car it is in. The railroad car is going due south at $.95 \mathrm{~m} / \mathrm{s}$. In what direction, is the marble going relative to the ground?

The figure below is included to clarify what is meant by "northeast relative to the railroad car." It depicts a railroad flatcar moving southward. The compass directions are painted on the railroad car, as is a dotted line with an arrowhead. The marble stays on the dotted line as it rolls on the railroad car toward the arrowhead.


Selected Answer: $\times$ Northeast
Correct Answer: $\checkmark$ In a southeasterly direction
Feedback: The southward motion of the train more than cancels the northward component of the marble's velocity relative to the train, but there is nothing to cancel the eastward component.

A person has a throwing speed of $30 \mathrm{~m} / \mathrm{s}$. That is, every time she throws something it travels at $30 \mathrm{~m} / \mathrm{s}$ relative to whatever she is standing on. Suppose she is standing on a bus which is moving due north at $35 \mathrm{~m} / \mathrm{s}$ and throws a ball, with her normal throwing speed, directly toward the rear of the bus. How fast and in what direction would the ball be moving horizontally relative to the street (prior to the ball hitting anything)?

Selected Answer: $\checkmark 5 \mathrm{~m} / \mathrm{s}$ northward
Correct Answer: $\checkmark 5 \mathrm{~m} / \mathrm{s}$ northward
Feedback: All right!

Consider northward to be the positive direction. The total horizontal velocity of the ball relative to the ground is the velocity of the ball relative to the bus $(-30 \mathrm{~m} / \mathrm{s})$ plus the velocity of the bus relative to the ground ( $35 \mathrm{~m} / \mathrm{s}$ ). The sum of these is $(+5 \mathrm{~m} / \mathrm{s}$ ) which means $5 \mathrm{~m} / \mathrm{s}$ northward. Note that at the same time the ball is moving horizontally it is also falling. This means its velocity has a vertical component. This contributes to the total velocity of the ball. But the question was not about the total velocity of the ball, it was only about the horizontal component of the velocity.

## Question 3

0 of 20 points
A person in a car which is going due east at a steady $35 \mathrm{~m} / \mathrm{s}$ points a rifle, whose muzzle velocity is $200 \mathrm{~m} / \mathrm{s}$ due south, and pulls the trigger. Ignore air resistance. Assume the bullet hits nothing for the first 0.5 seconds of its travel and the car keeps traveling east at $35 \mathrm{~m} / \mathrm{s}$.
0.25 seconds after the bullet is fired:


Selected Answer: $\times$ The car is farther east than the bullet is.
Correct Answer: $\checkmark$ Neither the bullet nor the car is farther east than the other.
Feedback: The bullet was moving eastward at $35 \mathrm{~m} / \mathrm{s}$ prior to being fired and it keeps on doing that (in addition to moving southward at $200 \mathrm{~m} / \mathrm{s}$ ) after it is fired. The car also continually moves eastward at $35 \mathrm{~m} / \mathrm{s}$ so the bullet and the car remain abreast of each other.

## Question 4

0 of 20 points
A person is operating a motorboat such that it is heading due east and if it were on still water it would be going due east at 12 mph . But it is not on still water. It is on a river. The boat has just left the west bank of the river which flows due north at 5 mph . In what direction is the boat actually going?


Selected Answer: $\times$ The boat is going due east.
Correct Answer: $\quad$ No other answer provided is correct.
Feedback: The boat is going in a direction which is east of northeast. It is important to note that northeast is a specific direction, 45 degrees north of east. It is to be contrasted with "in a northeasterly direction" which is a vague expression indicating a direction anywhere between north and east (excluding due north and due east).

## Question 5

0 of $\mathbf{2 0}$ points
Below is a bird's eye view of a bus traveling due north at 50 mph at the instant a pellet gun, pointed due east, is fired. The muzzle velocity of the gun is 25 mph . (The muzzle velocity is the speed of the pellet relative to the gun, in the direction in which the gun is pointing.) Which of the trajectories depicted in the diagram will the pellet follow relative to the road? Ignore air resistance.


Selected Answer: $\times$ a)
Correct Answer: $\checkmark$ f)
Feedback: Prior to the firing of the gun, the pellet is moving due north at 50 mph . It never stops doing that. After the gun is fired it is also moving 25 mph eastward. No horizontal forces act on the pellet after it is fired, so, as viewed from above, it moves in a straight line path. (Of course it is falling toward the street too but we can't see that from a top view.) The straight line path that best depicts a northward velocity of 50 mph plus an eastward velocity of 25 mph is path f .

## Review Assessment: Lec 12 Quiz

Name: Lec 12 Quiz
Status: Completed

Score: 0 out of 100 points

## Instructions:

## Question 1

0 of 50 points
A rock is released from rest from point $P$, a point near the surface of the earth, but high enough above the surface of the earth that it takes more than 4 seconds for the rock to hit the ground. 2 seconds after the release of the first rock a second rock is thrown straight downward from point $P$ with an initial speed of $10.0 \mathrm{~m} / \mathrm{s}$. Which of the following most correctly describes what happens after the release of the second rock but prior to any rock/rock or rock/ground collision?

## Selected Answer: <br> $\times$ The second rock continually gains on the first rock thus decreasing the separation of the rocks. <br> Correct Answer: $\checkmark$ The first rock continually gains on the second rock thus increasing the separation of the rocks.

Feedback: By the time the second rock is thrown downward at $10 \mathrm{~m} / \mathrm{s}$, the first rock has been accelerating (from rest) at $9.8 \mathrm{~m} / \mathrm{s}$ for two seconds. So the first rock has a velocity of $19.6 \mathrm{~m} / \mathrm{s}$ downward. From then on both rocks gain speed at the rate of $9.8 \mathrm{~m} / \mathrm{s}$ per second. Since they both gain speed at the same rate, the first rock will always be moving $9.6 \mathrm{~m} / \mathrm{s}$ faster than the second rock. So the first rock will continually gain on the second rock thus increasing the separation of the rocks.

A rock is thrown straight up. Neglecting air resistance, how does the speed of the rock when it reaches its release point on the way down compare with the speed it had upon release.
Selected
Answer:
Correct
Answer:

## Review Assessment: Lec 13 Quiz

Name: Lec 13 Quiz

## Status: Completed

Score: 22 out of 100 points

## Instructions:

Question 1
0 of 12 points
A rock is thrown up into the air at an angle of $75^{\circ}$ ab ove the horizontal. Neglect air resistance. The questions pertain only to the free-fall portion of the rock's flight. What is the direction of the acceleration of the rock: (Beside each question item select one answer item. Any answer item may be used more than once.)

Question Correct Match Selected Match
on the way up? $\quad \checkmark$ B. downward $\times$ A. upward
at the top of its flight? $\quad$ B. downward $\times \mathrm{A}$. upward
on the way down? $\quad \checkmark$ B. downward $\times \mathrm{A}$. upward
Feedback: Neglecting air resistance, an object in free fall always experiences an acceleration of $9.8 \mathrm{~m} / \mathrm{s}^{2}$ in the downward direction throughout its motion.

## Question 2

0 of 12 points
A rock is thrown with a velocity of $5.0 \mathrm{~m} / \mathrm{s}$ at $35^{\circ}$ above the horizontal. Ignore air resistance an d consider only the free-fall portion of the rock's flight. What is the $x$-component of the rock's velocity:

| Question | Correct <br> Match |
| :--- | :--- |
| at the instant after release? $\checkmark$ D. $4.1 \mathrm{~m} / \mathrm{s} \times \mathrm{A} .0 \mathrm{~m} / \mathrm{s}$ <br> Match  |  |
| at the top of its flight? | $\checkmark$ D. $4.1 \mathrm{~m} / \mathrm{s} \times \mathrm{A} .0 \mathrm{~m} / \mathrm{s}$ |
| on the way down, at the instant it achieves the elevation from which it was | $\checkmark \mathrm{D} .4 .1 \mathrm{~m} / \mathrm{s} \times \mathrm{A} .0 \mathrm{~m} / \mathrm{s}$ |

from which was released?

Feedback: There is no acceleration in the forward direction so the forward velocity never changes. It is always just the forward component of the initial velocity which is the initial velocity times the cosine of the launch angle.

$\frac{V_{0 x}}{V_{0}}=\cos \theta$


$$
V_{o x}=(5.0 \mathrm{~m} / \mathrm{s}) \cos 35^{\circ}
$$

$$
V_{0 x}=4.096 \mathrm{~m} / \mathrm{s}
$$

$$
v_{o x}=4.1 \mathrm{~m} / \mathrm{s}
$$

A rock is thrown with a velocity of $5.0 \mathrm{~m} / \mathrm{s}$ at $35^{\circ}$ above the horizontal. Ignore air resistance an consider only the free-fall portion of the rock's flight. Consider the forward direction to be the $x$-direction and upward to be the $y$-direction. What is the $y$-component of the rock's velocity:

| Question | Correct MatchSelected <br> Match |  |
| :--- | :--- | :--- |
| at the instant after release? | $\checkmark$ B. $2.9 \mathrm{~m} / \mathrm{s} \times \mathrm{A} .0 \mathrm{~m} / \mathrm{s}$ |  |
| at the top of its flight? | $\checkmark \mathrm{A} .0 \mathrm{~m} / \mathrm{s}$ | $\checkmark \mathrm{A} .0 \mathrm{~m} / \mathrm{s}$ |
| on the way down, at the instant it achieves the elevation from which it was <br> released? | C. -2.9 <br> $\mathrm{~m} / \mathrm{s}$ | $\times \mathrm{A} .0 \mathrm{~m} / \mathrm{s}$ |

Feedback: Below is the calculation for the y-component of the initial velocity of the rock. At the top of its motion, the y-component of the velocity is zero. If the velocity were not reduced to zero, the rock would still be going upward and it would not be at the top of its trajectory. Concerning any elevation which the rock achieves both on the way up and on the way down, a number of statements hold true. The time that it takes for the rock to get from that elevation up to the top of its trajectory is the same as the time that it takes for it to fall from the top of its trajectory back down to that elevation. Further, the speed of the rock is the same when the rock is on the way up at that elevation as it is when the rock is on the way down at that elevation. Since the horizontal component of the rock never changes this means that, at that elevation, the vertical component of the velocity has the same magnitude on the way up as it has on the way down. The only difference is the direction of the vertical component of the velocity. On the way up, the vertical component of the velocity is upward, or positive. On the way down, the vertical component of the velocity is downward (negative).


$$
\begin{aligned}
\frac{V_{0 y}}{V_{0}} & =\sin \theta \\
V_{0 y} & =V_{0} \sin \theta \\
V_{0 y} & =5.0 \frac{\mathrm{~m}}{3} \sin 35^{\circ} \\
& =2.87 \mathrm{~m} / \mathrm{s} \\
V_{0 y} & =2.9 \mathrm{~m} / \mathrm{s}
\end{aligned}
$$

A rock is thrown from a cliff. The initial velocity of the rock is $15 \mathrm{~m} / \mathrm{s}$ at an angle of $30^{\circ}$ below the horizontal. Which trajectory will the rock follow? Ignore air resistance.


The arrow labeled $v_{0}$
represents the initial
velocity of the rock.

Selected Answer: $\times \mathrm{a}$
Correct Answer: $\checkmark \mathrm{b}$
Feedback: At the start, the velocity of the rock has both a forward component and a downward component. The forward component does not change but there is a downward acceleration due to gravity. Hence the downward velocity continually increases. The result is a downward-curving trajectory. Trajectory dis the only one that has any curvature and its curvature is indeed downward.

A rock is thrown up into the air with an initial velocity of $7 \mathrm{~m} / \mathrm{s}$ at an angle of $65^{\circ}$ above the horizontal. The rock is released from a point that is 1.5 m above the ground which is flat and level. At the exact same instant that the rock is released, another rock is released from rest from the same height, 1.5 m , from which the first rock was released. Which rock, if either, hits the ground first?

Selected Answer: $\times$ They both hit at the same time.
Correct Answer: $\checkmark$ The dropped rock hits first.
Feedback: This situation is different from the case where one rock is thrown horizontally at the same time and elevation as a second rock is dropped. In the latter case, both rocks start out with the same vertical component of velocity, namely, zero. Hence their vertical motion is one and the same despite the fact that one of the rocks is moving horizontally as it falls. In the question asked here, however, the thrown rock starts out with a non-zero upward velocity where-as the dropped rock starts with no upward velocity. The thrown rock takes some time to go up to the point where its vertical velocity is zero and then fall from there to the ground. The dropped rock just falls from its release point to the ground. It falls a shorter distance plus it uses no time in going up since it never goes up. Hence the dropped rock hits the ground first.

## Question 6

0 of 9 points
A projectile is launched horizontally from a height of 12 meters above ground level at a speed of $22 \mathrm{~m} / \mathrm{s}$. What is the $x$-component of the initial velocity?


Selected Answer: $\times 0 \mathrm{~m} / \mathrm{s}$
Correct Answer: $\checkmark 22$ m/s
Feedback: By convention, for projectile motion, the forward direction is the positive x-direction and the upward direction is the positive y-direction. For a horizontal launch, the initial velocity of the object is in the x-direction. Hence the x-component of the initial velocity has the same magnitude as that of the initial velocity itself.

A projectile is launched horizontally from a height of 12 meters above ground level at a speed of $22 \mathrm{~m} / \mathrm{s}$. What is the $y$-component of the initial velocity?


Selected Answer: $\checkmark 0 \mathrm{~m} / \mathrm{s}$
Correct Answer: $\checkmark 0 \mathrm{~m} / \mathrm{s}$
Feedback: Well done! Since the initial velocity of the projectile is strictly in the x-direction, the y-component of the initial velocity is zero.

A projectile is launched horizontally from a height of 12 meters above ground level at a speed of $22 \mathrm{~m} / \mathrm{s}$. How long does it travel before hitting the ground?

Selected Answer: $\checkmark 1.6$ seconds
Correct Answer: $\checkmark 1.6$ seconds
Feedback: Nice work!
Did you show your work as has been done below? Multiple choice questions are an exception, but usually, the solution to a physics problem is judged to be more important than the answer.


$$
\begin{aligned}
& y \text {-motion determines time of Slight. } \\
& x^{0}=y_{0}+\text { Roy }_{0}^{0}+\frac{1}{2} a_{y} t^{2}
\end{aligned}
$$

$$
\frac{1}{2} a y t^{2}=-40
$$

$$
t^{2}=-\frac{2 y_{0}}{x_{y}}
$$

$$
t=\sqrt{-\frac{2 y_{0}}{x_{4}}}
$$

$$
t=\sqrt{\frac{-2(12 m)}{-9.8 \mathrm{~m} / 5^{2}}}=1.565
$$

$$
t=1 \cdot 65
$$

Question 9
0 of 9 points
A projectile is launched horizontally from a height of 12 meters above ground level at a speed of $22 \mathrm{~m} / \mathrm{s}$. How far forward does it go before hitting the ground?

Selected Answer: $\times 12$ meters
Correct Answer: $\checkmark 34$ meters
Feedback:

$$
\begin{aligned}
& x \text {-motion determines range of projectile. } \\
& \begin{array}{l}
\text { How far forward } \\
\text { it goes. }
\end{array} \\
& x=v_{0 x} t \\
& x=\left(22 \frac{\mathrm{~m}}{\mathrm{~s}}\right)(1.56 \mathrm{~s})=34.4 \mathrm{~m} \\
& x=34 \mathrm{~m}
\end{aligned}
$$

A projectile is launched horizontally from a height of 12 meters above ground level at a speed of $22 \mathrm{~m} / \mathrm{s}$. How fast is it going just before it hits the ground?

Selected Answer: $\times 15 \mathrm{~m} / \mathrm{s}$
Correct Answer: $\checkmark 27 \mathrm{~m} / \mathrm{s}$

## Feedback:

It moves forward at $22 \frac{\mathrm{~m}}{\mathrm{~s}}$
throughout its motion: $v_{x}=22 \mathrm{~m} / \mathrm{s}$
At end it is also moving downward:

$$
\begin{aligned}
& v_{y}={ }^{0} V_{a y}+a_{y} t \\
& v_{y}=-9.8 \frac{\mathrm{~m}}{\mathrm{~s}^{2}}(1.56 \mathrm{~s}) \\
& v_{y}=-15.3 \frac{\mathrm{~m}}{\mathrm{~s}}
\end{aligned}
$$

The total velocity is the vector sum of its horizontal velocity and its vertical velocity


$$
\begin{aligned}
V & =\sqrt{V_{x}^{2}+V_{y}^{2}} \\
& =\sqrt{(22 \mathrm{~m} / \mathrm{s})^{2}+(15.3 \mathrm{~m} / \mathrm{s})^{2}}=26.8 \mathrm{~m} / \mathrm{s} \\
V & =27 \mathrm{~m} / \mathrm{s}
\end{aligned}
$$

## Review Assessment: Lec 14 Quiz

| Name: | Lec 14 Quiz |
| :--- | :--- |
| Status : | Completed |
| Score: | 10 out of 100 points |

Instructions:

## Question 1

0 of 10 points
A karate expert hits a thick board with her hand. The board breaks. Why does the board break while the karate expert's hand does not?

Selected $\quad \times$ The karate expert hits the board, not the other way round. The karate expert does feel the board
Answer: but because she is the agent of the actual force, the force on the board is much greater than the force on her hand, the board breaks while her hand remains intact.

Correct $\quad \checkmark$ The force exerted on the hand by the board is just as great as the force exerted on the board by Answer: the hand. That magnitude of force is sufficient to break the board but it is not sufficient to break the hand. At the orientation of each at impact, the hand can withstand, without breaking, a greater force than the board can.

Question 2
10 of 10 points
Consider a cart pulled by a horse. How can the horse ever get the cart moving if, no matter how hard the horse pulls forward on the cart, the cart pulls backward just as hard on the horse.

Selected $\quad \checkmark$ The force of the cart pulling backward on the horse is not a force on the cart so it does not affect
Answer: the motion of the cart. The force of the horse on the cart is what causes the cart to accelerate forward.

Correct $\quad \checkmark$ The force of the cart pulling backward on the horse is not a force on the cart so it does not affect Answer: the motion of the cart. The force of the horse on the cart is what causes the cart to accelerate forward.

Feedback: Way to go!

## Question 3

0 of 10 points
In the case of a horse pulling a cart, if the cart is pulling backward on the horse just as hard as the horse pulls forward on the cart, how can the horse ever get going?

Selected $\quad \times$ The premise is wrong. The cart does not pull on the horse.
Answer:
Correct $\quad \checkmark$ The ground pushes the horse forward with a force that is greater than the force with which the
Answer: cart pulls backward on the horse. Hence there is a net forward force on the horse.

Feedback: To get going, the horse exerts its muscles so as to push backward on the ground with its hooves. But, by Newton's Third Law, if the hooves are pushing backward on the ground, the ground has to be pushing forward on the hooves just as hard. When the horse is getting started, this forward-directed force of the ground on the horse exceeds the backward-directed force of the cart on the horse, resulting in a forward acceleration of the horse.

What's the difference between mass and weight?

Selected $\quad \times$ There is no difference. They represent two different terms for the same thing.

## Answer:

Correct Answer:
$\checkmark$ Mass is a measure of an object's inertia, whereas weight is a measure of how hard the earth is pulling on an object.

## Question 5

## 0 of 10 points

A huge truck going 20 mph collides head-on with a small car also going 20 mph . The car is badly smashed and pushed backward whereas the truck is less damaged and continues forward. How does the force with which the truck pushes on the car compare with the force with which the car pushes on the truck during the collision?

Selected $\quad \times$ The car pushes harder on the truck. One can tell that this is the case because the car distorts Answer: itself in pushing on the truck more than the truck distorts itself pushing on the car.
Correct $\quad \checkmark$ The car pushes just as hard on the truck as the truck pushes on the car in accordance with Answer: Newton's third law. The car experiences a greater acceleration than the truck does because it has less mass.
Feedback: The statement that the car experiences more damage is not relevant. The only reason a truck would typically experience less damage than a car is that trucks are typically made of thicker metal.

## Question 6 <br> 0 of 10 points

Any object near the surface of the earth experiences a force known as the weight of said object. Name the agent of the weight force.

Selected Answer: $\times$ Inertia
Correct Answer: $\checkmark$ The earth.


Feedback: The agent of a force on an object is the "who" or "what" that is exerting that force on the object. "Gravity" is a topic heading. It cannot be the agent of any force. The kind of force exerted on the object does indeed fall under the topic heading of "gravity", but the "who" or "what" that exerts the gravitational force on an object is the earth. The gravitational force exerted on the object by the earth is the weight of the object.

Please click on the following link for further discussion of this question: weight.htm

## Question 7

0 of 10 points
Consider a car accelerating in the forward direction. What exerts the force on the car that causes the car to experience the forward acceleration.

Selected Answer: $\times$ The engine.
Correct Answer: $\checkmark$ No other answer provided is correct.
Feedback: The road exerts the force on the car. The engine causes at least two of the wheels to turn. Where these wheels make contact with the road they push backward on the road. The reaction force to this is a forward force on the wheels which are part of the car and hence a forward force on the car. The force is a frictional force.

## Question 8

0 of 10 points
Once an arrow is shot into the air, what exerts the force that makes the arrow keep on going downrange?
(Downrange is the horizontal direction away from the bow in which the arrow is going. The arrow also has some vertical motion.)

Selected $\times \mathrm{m} \cdot \mathrm{a}$.
Answer:
Correct $\quad \checkmark$ Nothing. The natural tendency of the arrow is to keep on moving forward at a constant velocity.

Answer: The earth does exert a gravitational force on the arrow in the downward direction which does affect the arrow's vertical motion, but this is not what keeps it going downrange.

Feedback: Note that the bowstring initiated the motion but it is no longer affecting the motion of the arrow once the arrow loses contact with the bow. Inertia is a measure of the inherent tendency of the arrow to keep on moving at constant velocity. It is not an agent that exerts a force. The earth pulls downward on the arrow. This affects the vertical motion of the arrow but not the downrange motion.

## Question 9

Judging from the free body diagram alone; given that $F_{\mathrm{P}}$ is the force exerted on the block by a person, $N$ is the normal force exerted on the block by the floor, $W$ is the weight of the block, and $a$ is the acceleration of the block; what is wrong with the following free body diagram?


Selected Answer: $\times$
The arrow representing the force of the person is pointing the wrong way.

## Correct Answer:

The acceleration arrow is touching the object.

Question 10
0 of 10 points
Which one of the equations below does not follow from the following free body diagram of a block of mass $m$ ?


Selected Answer: $\times F_{\mathrm{P}}+T=\mathrm{ma}$
Correct Answer: $\checkmark N-W=\mathrm{ma}$

## Feedback:

## Review Assessment: Lec 15 Quiz

Name: Lec 15 Quiz
Status : Completed
Score: 18 out of 100 points

## Instructions:

Question 1
18 of 24 points
A block is released from rest on a flat frictionless board which is tilted so that it slants down to the right. To help yourself with this question, draw a free body diagram for the block. Beside each direction given below, indicate the number of forces acting on the block in that direction.

## Question

Up the ramp.
Down the ramp.
Perpendicular to and into the ramp.
Perpendicular to and out of the ramp. Straight up.

Straight down.
Horizontal and to the right.
Horizontal and to the left.

## Correct Match

$\checkmark$ A. 0
$\checkmark$ A. 0
$\checkmark$ A. 0

- B. 1
$\checkmark$ A. 0
$\checkmark$ B. $1 \quad \times$ A. 0
$\checkmark$ A. 0
$\checkmark$ A. 0
$\checkmark$ A. 0

Feedback: There are only two forces acting on the block: 1. The weight force exerted on the block by the earth. 2. The normal force exerted on the block by the ramp. Note that the block experiences acceleration in the down-the-ramp direction despite the fact that there is no force directed exactly in the down-theramp direction. The weight force, can however, be broken up into components in the perpendicular-to-and-into-the-ramp direction and the down-the-ramp direction. It is the down-the-ramp component of the weight force that causes the block to accelerate down the ramp.


Question 2
A person pushes horizontally on a crate in the forward direction. The crate is on a rough surface. The crate accelerates forward without tipping. Draw the free body diagram for the crate and then indicate the number of forces on your diagram in each of the directions specified below. (You may use any answer item more than once. You do not have to use all the answer items.)

Question
Number of forces in the upward direction.

Correct Match Selected Match

Number of forces in the downward direction.
$\checkmark$ B. 1
$\times \mathrm{A} .0$

- B. 1
$\times \mathrm{A} .0$

Number of forces in the forward direction. $\checkmark$ B. $1 \times$ A. 0
Number of forces in the backward direction. $\checkmark$ B. $1 \times$ A. 0
Feedback: There is one force in each direction. Upward: The normal force exerted by the floor on the crate. Downward: The weight force exerted on the cart by the earth. Forward: The force of the person pushing on the crate. Backward: The frictional force exerted on the crate by the floor.


## Question 3

0 of 16 points
A block is sliding up a ramp in the straight-up-the-ramp direction which is also the up-and-to-the-right direction. The surface of the ramp is flat but not horizontal and not smooth. The block is in contact with nothing but the ramp. What is the direction of the acceleration of the block? (Choose the one best answer.)

```
Selected
Answer:
\(X\) In no direction. The acceleration is zero. Since there is no acceleration, there is no direction of acceleration.
Correct \(\quad \checkmark\) Down the ramp.
Answer:
```

Feedback: The effect of the down-the-ramp acceleration, resulting from both the frictional force and the down-the-ramp component of the weight of the block, is to slow the block.

A block is sliding up a ramp in the straight-up-the-ramp direction which is also the up-and-to-the-right direction. The surface of the ramp is flat but not horizontal and not smooth. The block is in contact with nothing but the ramp. Draw a free body diagram of the block. Beside each direction specified below, indicate the number of forces acting on the block in that direction.

## Question

Parallel to the surface of the ramp, up the ramp.

## Correct Match Selected Match

$\checkmark$ A. $0 \quad \checkmark$ A. 0

Parallel to the surface of the ramp, down the ramp.
Perpendicular to and into the ramp.
/B. 1
$\times \mathrm{A} .0$
$\checkmark$ A. 0
$\checkmark$ A. 0
Perpendicular to and out of the ramp.
Straight up.
Straight down.
Horizontal and to the right.
Horizontal and to the left.
$\checkmark$ B. 1
$\checkmark$ A. 0

- B. 1
A. 0
$\checkmark$ A. 0

Feedback: There are three forces on the block. 1. The normal force exerted on the block by the ramp. As the name implies, it is perpendicular to the surface of the ramp. It is directed away from (out of) the ramp. 2. The frictional force exerted on the block by the ramp. It's always directed opposite the direction of motion. The block is going up the ramp so the frictional force is in the down-the-ramp direction. 3. The weight of the block. This force is exerted on the block by the earth. The earth pulls on the block straight downward toward the center of the earth. One might be wondering how the block could be moving up the ramp if there is no force up the ramp. Recall that Newton's second law relates force and acceleration. Thus force causes continual change-in-velocity. Force does not cause velocity. In the case at hand there is a net force down the ramp and hence there is acceleration in the down-theramp direction. This just means that the block is slowing. How did the block ever get to be sliding up the ramp? That doesn't matter for purposes of relating its force and acceleration. It's part of the block's history. Perhaps someone kicked it. But that someone is not kicking it now so their kick is having no effect on the acceleration.


> N: NORMAL FORCE
> f: frictional force
> W: WEIGHT

Question 5
0 of 16 points
A horse is pulling a sleigh over flat level, snow-covered terrain when the sleigh hits a bare patch of ground causing the sleigh to be slowing down even though the horse is pulling directly forward on the sleigh. Which one of the following represents a correct, complete free body diagram for the sleigh under the given circumstances? (Consider the harness to be part of the horse.)

Selected Answer: $\times$


$$
\begin{array}{ll}
F_{s} \equiv \text { FORLE of sLEMGH } & W_{H} \equiv \text { Weight of horse } \\
f \equiv \text { Frictional force } & N_{H} \equiv \text { NORMAL FORLE } \\
W_{S} \equiv \text { Weight of sleigh } & \\
N_{S} \equiv \begin{array}{ll}
\text { Normal Force of HORCE } \\
& \text { Ground on sleigh }
\end{array} & F_{H} \equiv \text { FORCE OF HORSE }
\end{array}
$$

Correct Answer:


Feedback: The diagram that includes the horse is wrong because the sleigh is not drawn FREE of its surroundings. The answer that includes the bogus "force of motion" is also wrong. There is no such thing as the "force of motion."

## 园且 Review Assessment: Lec 16 Quiz

| Name: | Lec 16 Quiz |
| :--- | :--- |
| Status : | Completed |
| Score: | 20 out of 100 points |

## Instructions:

## Question 1

Below is depicted a block on a frictionless surface. It is attached by a spring to a wall. The unstretched length of the spring is 1.00 m . The spring is stretched so that its length as depicted in the diagram is 1.20 m . Because of the spring, the block is accelerating rightward at $2.3 \mathrm{~m} / \mathrm{s}^{2}$. What is the force constant (also known as the spring constant) for the spring?


Selected Answer: X . $44 \mathrm{~N} / \mathrm{m}$
Correct Answer: $\checkmark 250 \mathrm{~N} / \mathrm{m}$

## Feedback:

$$
\begin{aligned}
& L_{0}=1.00 \mathrm{~m} \text { (unstretehed length of spring) } \\
& L=1.20 \mathrm{~m} \text { (current length of spring) } \\
& X=L-L_{0} \text { (spring stretch) } \\
& =1.20 m-1.00 m \\
& x=.20 \mathrm{~m}
\end{aligned}
$$

$$
\begin{aligned}
& \sum F_{\rightarrow}=m a_{\rightarrow} \\
& F=m a \\
& k x=m a \\
& k=\frac{m a}{x} \\
& k=\frac{(22 \mathrm{~kg}) 2.3^{\mathrm{m} / \mathrm{s}^{2}}}{.20 \mathrm{~m}} \\
& k=253 \frac{\mathrm{~N}}{\mathrm{~m}} \\
& k=250 \frac{\mathrm{~N}}{\mathrm{~m}}
\end{aligned}
$$

Question 2
Depicted below is a block of mass 1.5 kg on a frictionless incline. The surface of the incline makes an angle of $12^{\circ}$ with the horizontal. What is the magnitude of the acceleration of the block?


Selected Answer: $\times 0 \mathrm{~m} / \mathrm{s}^{2}$
Correct Answer: $\checkmark 2.0 \mathrm{~m} / \mathrm{s}^{2}$
Feedback:


The diagram below depicts a person pushing horizontally on a crate on a horizontal surface which is not frictionless. The person is exerting a force of 320 N on the crate and the crate is accelerating forward at $1.0 \mathrm{~m} / \mathrm{s}^{2}$. Find the coefficient of kinetic friction governing the crate/floor interface.


Selected Answer: $\times 0$
Correct Answer: $\checkmark .27$
Feedback:

F: FORCE OF PERSON
N: NORMA FORCE
W: WEIGHT
f: FRICTIONAL FORLE
$f=\mu_{k} N$
NEED $N$
$\Sigma F_{T}=0$
$N-W=0$
$N=W \quad$ (use $W=m g$ ) $N=m g$ (SUBST INTO $f=\mu_{k} N$ )

$$
\begin{aligned}
& f= \mu_{k} m g \\
& \mu_{k}= \frac{f}{m g} \\
& N E E D f \\
& \sum F_{\rightarrow}=m a \\
& F-f=m a \\
& f=F-m a\left(\text { SuBST INTO } \mu_{k}=\frac{f}{m g}\right) \\
& \mu_{k}= \frac{F-m a}{m g} \\
&= \frac{320 \mathrm{~N}-88 \mathrm{~kg}\left(1.0 \mathrm{~m} / \mathrm{s}^{2}\right)}{88 \mathrm{~kg}\left(9.8 \frac{\mathrm{~N}}{\mathrm{~kg}}\right)} \\
&= .269 \quad \text { (ROuND TO } 2 \text { SIG FIGS) }
\end{aligned}
$$

(8)

The diagram below depicts two objects connected by a taut cord. One of the objects is sliding rightward on a frictionless surface while the other is descending. Consider the cord to be massless and the pulley to be massless and frictionless. What is the direction of the force exerted on the descending mass by the cord?


Selected Answer: $\checkmark$ upward
Correct Answer: $\checkmark$ upward
Feedback: Congratulations on a fine answer!
A cord exerts a force on an object at that point where the cord touches the object. The force is directed away from the object, along the length of the cord. In other words, "you can't push with a cord".

The diagram below depicts two objects connected by a taut cord. One of the objects is sliding rightward on a frictionless surface while the other is descending. Consider the cord to be massless and the pulley to be massless and frictionless. How does the magnitude of the tension in the cord compare with the weight of the descending object?


Selected Answer: $\times$ The tension in the cord is equal to the weight of the block.
Correct Answer: $\checkmark$ The tension in the cord is less than the weight of the block.
Feedback: The tension in the cord is the upward force exerted on the descending block by the string. This force and the block's own weight (the gravitational force of the earth on it) are the only forces acting on the descending block. Note that, as indicated in the diagram, the descending block is accelerating downward. If the tension pulling upward on the block was greater than the weight, the block would have to be accelerating upward. If the tension was the same as the weight, the block would not be accelerating at all. For it to be accelerating downward, there has to be a net downward force on the block. That means that the weight of the descending block must be greater than the tension.

## Review Assessment: Lec 17 Quiz

| Name: | Lec 17 Quiz |
| :--- | :--- |
| Status: | Completed |
| Score: | 40 out of 100 points |

## Instructions:

## Question 1

## 0 of $\mathbf{2 0}$ points

Point objects 1, 2, and 3 are all equidistant from each other. Objects 1 and 2 have one and the same mass. The mass of object 3 is twice that of object 1 . How does the force exerted upon object 1 by object 2 compare with the force exerted upon object 1 by object 3 .

Selected Answer: $\mathbf{X}$ The force of object 2 on object 1 is the same as the force of object 3 on object 1 .
Correct Answer: $\checkmark$ No other answer provided is correct.
Feedback: For all three objects to be separated by the same distance they must occupy the corners of an equilateral triangle. Hence, none of them is "in the middle". The force is directly proportional to the product of the masses. In the case of the force of 3 on 1 , just one of the masses is double the corresponding mass in the case of the force of 2 on 1 . Hence the force is twice as great. In other words, the force of 2 on 1 is one half the force of 3 on 1 . Since that answer does not appear the only correct answer is "e) No other answer provided is correct."

## Question 2

0 of $\mathbf{2 0}$ points
If any two objects that have mass exert an attractive gravitational force on each other, why is it possible for me to put two books on a desk without having them slide toward each other.

Selected $\times$ The gravitational force is only present if one of the objects is of mass comparable to that of the Answer: moon.

Correct $\quad \checkmark$ For two books, because of the small mass of each, the gravitational force is so small compared Answer: to the frictional force that the desk can exert on each book, that the effect of the force is unnoticeable.

Feedback: Consider two 1 kg books whose centers of mass are separated by 15 cm . We can approximate the gravitational force of attraction that one book exerts on the other by treating the books as if all the mass in each book was concentrated at the book's own center of mass. Then the gravitational force of attraction would be

$$
\begin{aligned}
& F=\frac{G m_{1} m_{2}}{r^{2}} \\
& F=\frac{6.67 \times 10^{-11} \frac{\mathrm{~N} \cdot \mathrm{~m}^{2}}{\mathrm{~kg}^{2}}(1 \mathrm{~kg})(1 \mathrm{~kg})}{(.15 \mathrm{~m})^{2}} \\
& F=3.0 \times 10^{-9} \mathrm{~N}
\end{aligned}
$$

Compare this with the maximum possible force of static friction, equivalent in magnitude to the sideways force that would have to be exerted on one of the books to budge it. Assuming the coefficient of static friction to be .3 , that force would be 3 N . Thus the gravitational force on the book would be about one billionth as strong as it would have to be in order to budge the book.

If the sun is pulling the earth directly toward the center of the sun, why hasn't the earth crashed into the sun?

Selected Answer: $\checkmark$ The earth's momentum keeps it from falling into the sun.
Correct Answer: $\checkmark$ The earth's momentum keeps it from falling into the sun.
Feedback: Well done! Consider the earth at any given instant. Its velocity is directed essentially tangent to its orbit. If there were no gravitational force exerted upon it by the sun, it would travel along a straight line path in the direction of its velocity. The force of the sun on the earth causes it to deviate from that straight line path. The deviation is just the right amount to keep it moving on its orbit. The degree of the earth's tendency to keep moving straight ahead is determined by both how much inertia the earth has (its mass), and how fast its going. The product of these two is the magnitude of the earth's momentum. If its momentum were suddenly reduced to zero, it would indeed fall straight into the sun.

Note that the gravitational force of the sun on the earth is indeed what provides the centripetal force on the earth necessary to keep it moving in a circle but this does not answer the question.

If you decrease the separation of two objects by one third, what happens to the gravitational force of attraction that each exerts upon the other?

Selected Answer: $\checkmark$ It becomes 9/4 what it was.
Correct Answer: $\checkmark$ It becomes 9/4 what it was.
Feedback: Nice work! The new separation is the original separation minus one third of the original separation. Hence the new separation is $2 / 3$ the original separation. In calculating the new force this factor is squared and inverted yielding a factor of 9/4.

Question 5
0 of 20 points
What happens to the gravitational force that one object exerts on another if you triple the separation of the two objects?

Selected Answer: $\times$ The force becomes 1/9 times less than what it was.
Correct Answer: $\checkmark$ The force becomes 1/9 of what it was.
Feedback: Note that the answer that states that the force becomes $1 / 9$ times less than what it was is different from the correct answer. It doesn't say $1 / 9$ times what, but the only force there is to multiply $1 / 9$ times is the original force. Suppose the original force is 9 newtons. Than $1 / 9$ times it is 1 newton. And 1/9 times less than the original force would be 1 newton less than the original force, namely 8 newtons. But the new force is actually $1 / 9$ of the original force, namely, 1 newton in this example.

## Review Assessment: Lec 18 Quiz

Name: Lec 18 Quiz
Status : Completed
Score: $\quad 40$ out of 100 points

## Instructions:

Consider a person in the passenger seat of a car that is in the process of making a left turn at a constant speed. The passenger feels as if she is being pressed against the door of the car. Why?

Selected $\quad \checkmark$ A person's inertia, that natural tendency to move in a straight line path, feels, to a person in a Answer: car going around on a part of a circular path, like a force directed away from the center of the circle. This is what she feels.

Correct $\quad \checkmark$ A person's inertia, that natural tendency to move in a straight line path, feels, to a person in a Answer: car going around on a part of a circular path, like a force directed away from the center of the circle. This is what she feels.

Feedback: Nice work!
The pseudo-force that one definitely feels is called the centrifugal force. It is directed away from the center of the circle one is moving on. It is not a real force but rather one's own tendency to keep on moving in a straight path at constant speed.

Since the person is moving on a circular path she must be experiencing a real centripetal force. This is provided by the door which is pressing against her.

Note that the reaction force to the frictional force of the track on the wheels is a force on the track, not on the person, so the person will not feel it.

Its easy to tell that what she feels is not the centripetal force as the centripetal force is pushing the person toward the driver, not toward the door on her side of the car.

For more on this kind of pseudo-force click on the following link:
pseudo force.htm

For an object in uniform circular motion the acceleration is directed:

Selected Answer: $\checkmark$ toward the center of the circle on which the object is moving.
Correct Answer: $\quad \checkmark$ toward the center of the circle on which the object is moving.
Feedback: Yes!
The acceleration in question is the centripetal acceleration of the object. "Centripetal" means centerdirected. Below is the derivation for the direction of the average acceleration during the time that it takes an object in uniform circular motion to move from one point on a circle to a nearby point.
REGARDING THE DIRECTION OF THE
ACCELERATION OF AN OBJECT IN
UNIFORM CIRCULAR MOTION
 object is at point $B$ at time $t_{B}$

$$
\Delta t=t_{B}-t_{A} \quad \text { (time to get from } A \text { to } B \text { ) }
$$

Recall that the adjective "uniform" in uniform circular motion implies that the speed of the object that is moving in a circle is constant. Which of the following statements about the acceleration of an object undergoing uniform circular motion is most correct?

Selected Answer: $\times$ The acceleration of the object is zero.
Correct Answer: $\checkmark$ The magnitude of the acceleration is constant.

Feedback: The fact that the speed of an object in uniform circular motion is constant might suggest that the acceleration of the object is zero. But acceleration is the rate of change of velocity, not the rate of change of speed. Speed is the magnitude of velocity, but velocity has direction too. The direction of the velocity of an object in circular motion is continually changing. The acceleration is directed toward the center of the circle. It is called centripetal acceleration. For an object in circular motion, how fast the direction of its velocity is changing (its centripetal acceleration) depends on how fast it is going (its speed) and how big the circle is that its moving on.

$$
a_{c}=v^{2} / r
$$

Since $v$ and $r$ are constant for an object in uniform circular motion, the magnitude of the centripetal acceleration is constant.

For more information on what we mean by the magnitude of the centripital acceleration, click on the following link:
magnitude.htm

Consider a car going around a circular track at constant speed. What exerts the force on the car that causes the acceleration that the car is experiencing?

Selected Answer: $\times$ The car experiences no acceleration so nothing is exerting such a force.
Correct Answer: $\checkmark$ No other answer provided is correct.
Feedback: The track exerts a (sideways) frictional force on the car to provide the centripetal acceleration that the car is experiencing.

Question 5
0 of 20 points
Consider two people on a merry-go-round which has a constant spin rate. Harry is sitting on the merry-go-round 1 meter from the center. Jane is sitting on the merry-go-round 2 meters from the center. Which, if either has the greater speed.

Selected Answer: $\times$ They both have the same speed.
Correct Answer: $\checkmark$ Jane is going faster.
Feedback: Jane has the greater speed. Each time the merry-go-round spins once, she moves all the way around the circumference of the larger circle while Harry moves around the perimeter of the smaller circle. Since she covers a greater distance in the same amount of time she must be going faster.

## Preview Assessment Lec 19 Quiz

## Name: Lec 19 Quiz

## Instructions:

Multiple Attempts: This Test allows multiple attempts.
Force Completion: This Test can be saved and resumed later.

## - Question Completion Status:

## Question 1

13 points
How many radians are there in a circle?

- 360
No other answer provided is correct.


## Question 2

13 points
What is angular acceleration?How fast and which way an object is spinning.How fast and which way a point on a spinning object is moving.How fast and which way the spin rate of an object is changing.How fast and which way the speed and direction of motion of a point on a spinning object is changing.No other answer provided is correct.

## Question 3

13 points
What is angular velocity?How fast and which way an object is spinning.How fast and which way a point on a spinning object is moving.How fast and which way the spin rate of an object is changing.How fast and which way the speed and/or direction of motion of a point on a spinning object is changing.No other answer provided is correct.

What symbol is used to represent angular acceleration?lower-case omegaupper-case omegalower-case alphaupper-case alpha
No other answer provided is correct.

## Question 5

12 points
What symbol is used to represent angular velocity?v-sub-aupper-case omegalower-case omegaupper-case alphalower-case alphaNo other answer provided is correct.

## Question 6

12 points
Save
A person is pedaling her bicycle along a straight path such that both wheels (each of which has a diameter of .820 meters and is rolling without slipping) have an angular acceleration of 2.40 radians per second. What is the acceleration of the bike?$.171 \mathrm{~m} / \mathrm{s}^{2}$
$.342 \mathrm{~m} / \mathrm{s}^{2}$
$.984 \mathrm{~m} / \mathrm{s}^{2}$
$1.97 \mathrm{~m} / \mathrm{s}^{2}$
$2.93 \mathrm{~m} / \mathrm{s}^{2}$
$5.85 \mathrm{~m} / \mathrm{s}^{2}$

## Question 7

## 12 points

A solid cylinder of radius 0.25 m is mounted on a thin horizontal rod through the center of the cylinder and perpendicular to the base of the cylinder. The cylinder is free to rotate, without friction, on the rod. A person holds the cylinder in a fixed position while taping one end of a piece of string to the wall of the cylinder and then wrapping the string several turns around the circumference of the cylinder. The thickness of the string is negligible. The person ties an object onto the other end of the string and lets that object hang there at rest. Finally, the person lets go of the cylinder. The string unwinds from the cylinder as the object drops with an acceleration of $6.0 \mathrm{~m} / \mathrm{s}^{2}$. What is the angular acceleration of the cylinder?0$0.042 \mathrm{rad} / \mathrm{s}^{2}$$4.0 \mathrm{rad} / \mathrm{s}^{2}$$16 \mathrm{rad} / \mathrm{s}^{2}$No other answer provided is correct.

A disk of radius 1.20 m is rotating about its axis of symmetry with an angular velocity of $5.0 \mathrm{rad} / \mathrm{s}$. What is the speed of a point, on the disk, that is 0.40 m from the rim?$.24 \mathrm{~m} / \mathrm{s}$$4.2 \mathrm{~m} / \mathrm{s}$$6.0 \mathrm{~m} / \mathrm{s}$No other answer provided is correct.

## Review Assessment: Lec 20 Quiz

Name: Lec 20 Quiz
Status: Completed
Score: 0 out of 100 points

## Instructions:

## Question 1

0 of 10 points
What is meant by the expression "Moment Arm". (Indicate all the answers that are correct.)

Selected $\quad \times$ It's a synonym for the expression "rotational inertia".
Answers:
Correct $\quad \checkmark$ It's what you multiply the magnitude of the force by to get the magnitude of the torque.
Answers: $\quad \checkmark$ It's the distance from the axis of rotation to the line of action of the force measured along an imaginary line which is perpendicular to the line of action of the force.

An object is constrained to rotate on a fixed axis. A force is exerted on the object. The resulting non-zero torque on the object, with respect to the axis of rotation, does not depend on:

Selected Answer: $\mathbf{X}$ the position of the point of application of the force.
Correct Answer: $\checkmark$ the moment of inertia of the object.
Feedback: The moment of inertia of the object is an inherent characteristic of the object itself. It plays no role in determining the torque. But it does play a role in determining the angular acceleration that results from that torque.

Question 3
0 of 10 points
Below is depicted a door. With respect to the door hinge, what is the moment arm for the 5.0 N force?


Selected Answer: $\times 6.0$ N•m
Correct Answer: $\checkmark$ No other answer provided is correct.

## Feedback:



## Question 4

0 of 10 points
Consider a car wheel that is one of the wheels that is not connected to a drive shaft, such as a rear wheel on a front-wheel-drive car. Assume the wheel to be ideal (that is, there is no frictional torque exerted by the axle on the wheel, and, the normal force is directed through the axis of rotation). Suppose that the wheel is on a car that has a forward velocity and a forward acceleration. Further suppose that the wheel is rolling without slipping. Now because the wheel is attached to the car, and the car is accelerating forward, the wheel itself (its center of mass), must be accelerating in the forward direction.

Now consider the wheel from the viewpoint of a person who sees the wheel traveling to her right. From that viewpoint, for the wheel to be rolling without slipping it must be rotating clockwise on the axle of the car. Furthermore, since the car is accelerating forward, the angular velocity must be increasing in order for the wheel to continue rolling without slipping. For that to be the case there must be a clockwise torque on the wheel. The torque associated with the frictional force exerted on the bottom of the wheel by the road can only be clockwise if the frictional force is in the backward direction. But if we consider the motion of the wheel itself (as opposed to looking at the car as a whole), how could the wheel be accelerating forward if the frictional force is in the backward direction?

## Selected Answer:

Correct $\quad$ The force of the axle on the wheel has a component in the forward direction which exceeds
Answer:
Feedback: In the free body diagram for the wheel below:
f is the static frictional force exerted on the wheel by the road.
N is the normal force exerted on the wheel by the road.
$F_{Y}$ is the force of the car pressing down on the hub of the wheel. (If the wheel fell off, the corner of the car would fall down. To keep it from falling down, the wheel must be exerting an upward support force on the car. $F_{Y}$ is the reaction force to that support force.)
$F_{X}$ is the forward force exerted on the wheel by the car. (As the rest of the car, including the axle on which the wheel in question is mounted, accelerates forward, the axle pushes forward on the hub of the wheel with force $F_{X}$.)

W is the weight of the wheel.
$F_{X}$ is greater than $f$. Thus, the net force $F_{X}-f$ in the forward direction is positive and this is what causes the wheel to accelerate forward with the car. The only force whose line of action does not pass through the axis of rotation of the wheel is $f$, thus $f$ is the only force causing torque and by inspection, that torque is indeed clockwise from the viewpoint in which the car is going rightward.


## Question 5

0 of 10 points
Consider the door depicted below. Someone is pushing on the door with a force of 5.0 Newtons. With respect to the door hinge, what is the torque on the door?


Selected Answer: $\times 6.6 \mathrm{~N} \cdot \mathrm{~m}$
Correct Answer: $\checkmark 6.0 \mathrm{~N} \cdot \mathrm{~m}$
Feedback:

$$
\begin{aligned}
\tau & =r_{1} F \\
& =(1.2 \mathrm{~m}) 5.0 \mathrm{~N} \\
\tau & =6.0 \mathrm{~N} \cdot \mathrm{~m}
\end{aligned}
$$

Depicted below is a wheel of a car. The driver is stepping on the gas causing the motor to apply a torque to the transmission which applies a torque to the drive shaft which applies a torque to the axle which applies a torque to the wheel. In principle, the motor is applying a torque to the wheel. This would tend to cause the wheel to spin faster but it is in contact with the road and the wheel is not slipping on the road. The impending sliding motion of the bottom-
most point on the wheel is backward (leftward in the diagram). The static frictional force is in the direction opposite the impending motion of that point in contact road, so the static frictional force $\mathrm{f}_{\text {ROAD }}$ is forward (rightward in the diagram). It is this force which causes the forward acceleration that occurs when one depresses the gas pedal with the motor running, the brakes off and the car in a forward gear.

Assuming the wheel is rolling without slipping, if the car is accelerating forward, the clockwise spin rate of the wheel must be increasing. But, in exerting the frictional force $f_{\text {ROAD }}$ where and in the direction it does exert the frictional force, the road is also exerting a counterclockwise torque (of magnitude $r \cdot f_{\text {ROAD }}$ where $r$ is the radius of the wheel) on the wheel. This would tend to cause the clockwise spin rate of the wheel to be decreasing. How can the clockwise spin rate of the wheel actually be increasing when the road exerts a counterclockwise torque on the wheel?


$$
\begin{array}{ll}
\text { Selected } & \text { X The counterclockwise torque exerted on the wheel by the road is negative. A negative } \\
\text { Answer: } & \text { clockwise torque is actually a clockwise torque. } \\
\text { Correct } & \text { The torque exerted by the motor (via the drive components) on the wheel is greater than the } \\
\text { Answer: } & \text { torque exerted by the road on the wheel. }
\end{array}
$$

Feedback: It is the net torque on the wheel that determines its angular acceleration. Because the clockwise torque due to the motor exceeds the counterclockwise torque exerted on the wheel by the road, the angular acceleration is clockwise.

## Question 7

0 of 10 points
What does torque cause?

Selected Answer: $\times$ Angular Position
Correct Answer: $\checkmark$ Angular Acceleration
Feedback: A net torque applied to an object causes the angular velocity of that object to be changing at a rate determined by the magnitude of the torque and the rotational inertia of the object. That is, it causes the object to experience angular acceleration.

If you begin to think that torque causes angular velocity (which is not true), consider the case of a counterclockwise torque applied to an object that is already spinning clockwise. The effect is for the object to slow down. That is, the angular velocity decreases. Rather than causing the object to have angular velocity, it is actually causing the object to lose angular velocity as time goes by.

## Question 8

A net torque of $0.012 \mathrm{~N} \cdot \mathrm{~m}$ is applied to the blade of an electric mixer. The moment of inertia of the mixer is 0.00025 $\mathrm{kg} \cdot \mathrm{m}^{2}$. What is the magnitude of the angular acceleration of the blade?

Selected Answer: $\times 0.0000030 \mathrm{rad} / \mathrm{s}^{2}$
Correct Answer: $\checkmark 48 \mathrm{rad} / \mathrm{s}^{2}$
Feedback:

$$
\begin{aligned}
& \tau=I \alpha \\
& \alpha=\frac{\tau}{I} \\
& \alpha=\frac{.012 \mathrm{~N} \cdot \mathrm{~m}}{.00025 \mathrm{~kg} \cdot \mathrm{~m}^{2}} \\
& \alpha=48 \frac{\mathrm{rad}}{\mathrm{~s}^{2}}
\end{aligned}
$$

The moment of inertia of an object plays a role in Newton's Second Law for Rotational Motion that is analogous to the role played by $\qquad$ in Newton's Second Law.

Selected Answer: $\times$ position
Correct Answer: $\checkmark$ No other answer provided is correct.
Feedback: The moment of inertia of an object, also known as the rotational inertia of the object, is a measure of the object's inherent resistance to a change in how fast it's spinning. This is analogous to the mass of an object or the inertia of an object. The mass of an object is a measure of that object's inertia, the object's inherent resistance to a change in how fast it is going. Neither mass nor inertia are listed among the possible answers so one must choose "No other answer provided is correct".

## Question 10

## 0 of 10 points

To determine the moment of inertia of a wheel, a net torque of $15 \mathrm{~N} \cdot \mathrm{~m}$ is applied to the wheel and the resulting angular acceleration of the wheel is measured. The angular acceleration is measured to be $5.6 \mathrm{rad} / \mathrm{s}^{2}$. What is the value of the moment of inertia of the wheel?

Selected Answer: $\times 0.37 \mathrm{~kg} \cdot \mathrm{~m}^{2}$
Correct Answer: $\quad \checkmark 2.7 \mathrm{~kg} \cdot \mathrm{~m}^{2}$

## Feedback:



$$
\begin{aligned}
& I=I \alpha \\
& I=\frac{\tau}{\alpha} \\
& I=\frac{15 N \cdot m}{5.6 \frac{\mathrm{rad}}{\mathrm{~s}^{2}}} \\
& I=2.679 \mathrm{~kg} \cdot \mathrm{~m}^{2} \\
& I=2.7 \mathrm{~kg} \cdot \mathrm{~m}^{2}
\end{aligned}
$$

## Review Assessment: Lec 21 Quiz

Name: Lec 21 Quiz

Status : Completed
Score: $\quad 30$ out of 100 points

## Instructions:

Question 1
0 of $\mathbf{2 0}$ points
Conceptually, the magnitude of the cross product of two vectors is:

Selected Answer: X a measure of the degree to which the two vectors are parallel to each other.
Correct Answer: $\checkmark$ a measure of the degree to which the two vectors are perpendicular to each other.

## Question 2

Indicate the answer that is equivalent to:
$\hat{\jmath} \times \hat{\mathbf{1}}, \hat{\jmath} \times \hat{\jmath}, \hat{\jmath} \times \hat{k}$

Selected Answer: X
$\hat{k}, 0,-\hat{\imath}$
Correct Answer:
$-\hat{k}, \quad 0, \quad \hat{\imath}$

## Question 3

15 of 15 points
When calculating the sum of two vectors, the order in which one adds the vectors does not matter.

Selected Answer: $\nearrow$ True
Correct Answer: $\checkmark$ True
Feedback: Well done.

## Question 4

0 of 15 points
When calculating the cross product of two vectors, the order in which the vectors are cross multiplied does not matter.

Selected Answer: $\times$ True
Correct Answer: $\checkmark$ False
Feedback: Reversing the order of the vectors in the cross product reverses the direction of the "answer" vector.

## Question 5

15 of 15 points
The torque with respect to a point in space (call it point P), due to a force, is the cross product of the postion vector of the point of application of the force, relative to point $P$, and the force in question.

Selected Answer: $\checkmark$ True
Correct Answer: $\checkmark$ True
Feedback: Nice job!

The position vector of the point of application of the force, used to calculate the torque caused by that force, is a vector that extends from the point of application of the force, to the axis with respect to which the torque is being calculated.

Selected Answer: $\times$ True
Correct Answer: $\checkmark$ False
Feedback: The position vector is used when one is calculating a torque with respect to a point, not an axis. Call that point, point $P$. The position vector extends from point $P$ to the point of application of the force, not vice versa.

## Review Assessment: Lec 22 Quiz

Name: Lec 22 Quiz<br>Status: Completed<br>Score: $\quad 40$ out of 100 points

Instructions:

## Question 1

## 0 of 20 points

A 1.00 m long, thin, uniform wooden rod lies on the x axis of a Cartesian coordinate system with one end at the origin and one end at $x=1.00 \mathrm{~m}$. An identical rod is positioned on the y axis with one end at the origin and one end at $y=1.00 \mathrm{~m}$. The center of mass of the pair of rods is at the midpoint (call it point $P$ with coordinates $x, y$ ) of the line segment that extends from the center of one rod to the center of the other. Now the rod on the x axis is replaced with a uniform, thin, metal rod of the same length as the wooden one but of greater mass. Again, one end of it is at the origin and the other is at $x=1.00 \mathrm{~m}$. Call the position of the center of mass of the mixed pair of rods (the wooden one along the y axis and the metal one along the x axis) point $\mathrm{P}^{\prime}$ with coordinates $\mathrm{x}^{\prime}, \mathrm{y}^{\prime}$. How do the values of the coordinates of the center of mass of the mixed pair of rods compare with the values of the coordinates of the center of mass of the original pair of wooden rods?

Selected Answer: $\mathrm{X} \mathrm{x}^{\prime}<\mathrm{x}, \mathrm{y}^{\prime}<\mathrm{y}$
Correct Answer: $\checkmark x^{\prime}>x, y^{\prime}<y$

## Question 2

0 of 20 points
Consider a thin rod of length 4L. Suppose you know the rod's moment of inertia I with respect to an axis perpendicular to the rod and passing through one end of the rod. Further suppose that you want to find the moment of inertia of the rod with respect to an axis perpendicular to the rod and passing through the rod at a point that is a distance $L$ from the same end of the rod mentioned above. Would it be correct to say that the moment of inertia about the new axis is $I+m L^{2}$ where $m$ is the mass of the rod?

Selected Answer: X Yes.
Correct Answer: $\checkmark$ No.
Feedback: The parallel axis theorem relates the moment of inertia of an object with respect to an axis passing through the center of the object and an axis that is parallel to that axis. In other words, one of the two axes must pass through the center of mass. In the case at hand, neither axis passes through the center of mass. so, we can't just use the parallel axis theorem once to get the moment of inertia of the rod of length $4 L$ to get the rod's moment of inertia with respect to an axis through a point that is a distance $L$ from one end of the rod.

Instead, we apply the parallel axis theorem twice; once to find that the rod's moment of inertia with respect to a parallel (to the given axis through the end of the rod) axis through the center of mass of the rod is $I-4 L^{2}$ and then, using that result, we apply the parallel axis theorem again to find that the moment of inertia of a parallel axis through a point that is a distance $L$ from the end of the rod (and hence a distance $L$ from the center of mass of the rod) is $I-3 L^{2}$.

Some meter sticks, four of them to be exact, are arranged on the floor in the shape of a square. Looking down on it from a position outside the square, you identify the meter stick nearest you as the bottom of the square, the one farthest from you as the top, the one to your right as the right side of the square and the one to your left as the left side of the square. Now you remove the top and right side of the square, leaving a pair of meter sticks arranged in the shape of an L . Where is the center of mass of the $L$ ?

## Answer:

Correct Answer: $\checkmark$ Between the point that was the center of the square and the point where the two rulers meet.

## Question 4

20 of 20 points
Consider a uniform flat metal plate cut out in an irregular shape whose dimensions are known to you. Which of the following would be a valid way of determining that axis perpendicular to the plate, with respect to which, the moment of inertia of the plate is a minimum?


Selected $\quad \checkmark$ Find the center of mass. The perpendicular-to-the-plate axis in question is the one that Answer: passes through the center of mass.
Correct $\quad \checkmark$ Find the center of mass. The perpendicular-to-the-plate axis in question is the one that Answer: passes through the center of mass.

Feedback: Nice job!

Consider a uniform flat metal plate in the shape of a right triangle. One leg of the triangle is horizontal, call it the base. The left leg of the triangle is vertical. The remaining leg of the triangle is, of course, the hypotenuse. Now consider a vertical line that is a perpendicular bisector of the base of the triangle. Which of the following is true about the position of the center of mass of the plate?

Selected Answer: $\checkmark$ The center of mass is to the left of the perpendicular bisector.
Correct Answer: $\checkmark$ The center of mass is to the left of the perpendicular bisector.
Feedback: Nice work!

## Review Assessment: Lec 23 Quiz

Name: Lec 23 Quiz
Status: Completed

Score: $\quad 10$ out of 100 points

## Instructions:

Question 1

## 0 of 10 points

A basketball (mass .60 kg ) is dropped from the top of the Empire State Building. At first it accelerates toward the pavement below at $9.8 \mathrm{~m} / \mathrm{s}^{2}$ but air resistance builds up as the speed of the ball increases. Air resistance never slows the ball, but it keeps it from gaining speed as rapidly as it would in the absence of air resistance. Eventually, the air resistance becomes so great that the ball stops speeding up. Neither does it slow down however. It keeps falling at a speed called the terminal velocity. As it falls at the terminal velocity, what is the magnitude of the drag force? (The drag force is the name of the air resistance force.)

Selected $\quad \times$ The drag force is in the upward direction but the magnitude cannot be determined without Answer: more information.

Correct
$\checkmark 5.9 \mathrm{~N}$ in the upward direction.
Answer:

## Feedback:




$$
\begin{aligned}
& \sum F_{A}=0 \\
& F_{D R A G}-W=0 \\
& F_{D R A G}=W \\
& \text { but } W=m g \text { so: } \\
& F_{D R A G}=m g \\
& \\
& =(.60 \mathrm{~kg}) 9.8 \frac{\mathrm{~N}}{\mathrm{~kg}} \\
& F_{\text {DRAG }}
\end{aligned}=5.88 \mathrm{~N} .
$$

## Question 2

0 of 10 points
A horse pulls a sleigh at constant velocity. To do so the horse maintains a constant forward force of 185 Newtons on the sleigh. Neglecting air resistance, find the frictional force exerted on the sleigh by the surface over which the sleigh is being pulled.

Selected $\quad \times$ The frictional force is in the backward direction (the direction opposite to the direction in which
Answer: the sleigh is going) but the magnitude cannot be determined without more information.

Correct $\quad \checkmark$ The frictional force is 185 N in the backward direction.
Answer:
Feedback: Given that the velocity is constant we know that the net force (net in this context is just another word for total) on the sleigh has to be zero. To cancel out the 185 N forward force of the horse on the sleigh, the frictional force must be 185 N in the opposite direction.

A person is pulling a 105 kg crate straight across a cement floor at a steady speed of $1.5 \mathrm{~m} / \mathrm{s}$ by means of a rope attached to the crate. The rope makes an angle of 18 degrees with the horizontal and the person is pulling on it with a force of 58 Newtons. What is the magnitude of the net force on the crate?

Selected Answer: $\checkmark$ ON

## Correct Answer: $\checkmark$ ON

Feedback: Nice work! The velocity of the crate is constant. This means that the acceleration of the crate is zero, hence, the net force on the crate must be zero.

## Question 4

0 of 10 points
Consider a car of mass 1100 kg traveling on a straight road at a steady 55 mph . Do not neglect air resistance. What is the net force acting on the car?

Selected $\quad \times$ The net force is in the backward direction (the direction opposite to the direction in which the
Answer: car is going) but the magnitude cannot be determined without more information.

Correct
$\checkmark 0 N$
Answer:
Feedback: The car is moving at constant velocity so the acceleration (how fast and which way the velocity is changing) is zero. The converse of Newton's First Law is that if the acceleration of an object is zero then the net force on that object is zero. Note that a 0-newton force is no force at all so there is no direction associated with it.

## Question 5

0 of 10 points
Consider the beam depicted below. It is supported by means of a pin at its left end and a rope at its right end. What is the direction of the force exerted on the beam by the rope at its right end?


Selected Answer: $\times$ leftward
Correct Answer: $\checkmark$ upward and to the left along the line containing the rope segment
Feedback: A rope exerts a force on an object at the point where the rope is fastened to the object. The force is directed along the rope, away from the point at which the rope is fastened to the object.

## Question 6

0 of 10 points
Consider the horizontal beam depicted below. It is supported by two fulcrums. A weight is suspended from the right end of the beam by means of a massless rope segment. What is the direction of the force exerted on the beam by the fulcrum that is 0.80 meters from the left end of the beam?


Selected Answer: X leftward
Correct Answer: $\checkmark$ upward
Feedback: If this fulcrum were suddenly removed, the beam would fall downward, so this fulcrum must be exerting an upward force on the beam.

Consider the horizontal beam depicted below. It is supported by means of a pin at its left end and a vertical segment of rope at its right end. A weight is suspended from the beam. What is the direction of the force exerted on the beam by the pin at the left end of the beam?


Selected Answer: $\times$ leftward
Correct Answer: $\checkmark$ upward
Feedback: If the pin were removed, the left end of the beam would initially go downward. To prevent this, the pin must be exerting an upward force on the beam.

In general, the force exerted by a pin such as that depicted above could have a horizontal component as well as a vertical component. In this problem, if one assumed that the force of the pin had a horizontal component (for instance if one speculated that the force was up and to the right), that component would represent the only horizontal force on the beam. For the beam to be in equilibrium, one would quickly arrive at the conclusion that the magnitude of the horizontal component of the force of the pin on the beam would have to be zero. (For equilibrium the net horizontal force has to be zero. If the only horizontal force is the horizontal component of the force of the pin, then for the net, or total, horizontal force to be zero, the horizontal component of the force of the pin has to be zero.)

## Question 8

0 of 10 points
Consider the horizontal beam depicted below. It is supported by two fulcrums. A weight is suspended from the right end of the beam by means of a massless rope segment. What is the direction of the force exerted on the beam by the fulcrum at the left end of the beam?


Selected Answer: $\times$ leftward
Correct Answer: $\checkmark$ downward
Feedback: If the fulcrum at the left end of the beam were suddenly removed, the beam would rotate clockwise. The right end of the beam would go down and the left end would go up. To prevent the left end from going up, the fulcrum on the left must be exerting a downward force on the beam.

Question 9
0 of 10 points
Depicted below is a crate of mass $m_{1}=150 \mathrm{~kg}$ (good to 2 significant digits) at rest on the floor. Attached to the top of a crate is one end of a massless cord. The cord passes over a frictionless pulley. Hanging from the other end of the cord is an object of mass $\mathrm{m}_{2}=85 \mathrm{~kg}$.

Find the tension in the cord.


Selected Answer: $\times$ Zero.
Correct Answer: $\checkmark 830 \mathrm{~N}$ (good to 2 significant digits)
Feedback: When you want to find the tension in a cord, draw a free body diagram for an object to which the cord is attached. The cord exerts its force of tension on that object, in the direction "away from the object and along the cord". The cord exerts an upward force on $m_{1}$ and an upward force on $m_{2}$. Draw and evaluate the free body diagram for $m_{2}$ to get the tension. The other object has the floor exerting an unknown normal force on it in the upward direction. If you drew and attempted to evaluate the free body diagram for it, you would not be able to solve for the tension.

$$
\begin{aligned}
& \Sigma F_{\uparrow}=0 \\
& T-m_{2} g=0 \\
& T=m_{2} \quad \uparrow \\
& T=(85 \mathrm{~kg})\left(9.8 \frac{\mathrm{~N}}{\mathrm{~kg}}\right) \\
& T=833 \mathrm{~N} \\
& T=830 \mathrm{~N}
\end{aligned}
$$

Depicted below is a crate of mass $m_{1}=150 \mathrm{~kg}$ (good to 2 significant digits) at rest on the floor. Attached to the top of a crate is one end of a massless cord. The cord passes over a frictionless pulley. Hanging from the other end of the cord is an object of mass $\mathrm{m}_{2}=85 \mathrm{~kg}$.

What is the weight of the crate?


Selected Answer: $\times$ Zero
Correct Answer: $\checkmark$ No other answer provided is correct.

Feedback:

$$
\begin{aligned}
& W_{1}=m_{1} g \\
& W_{1}=150 \mathrm{~kg}\left(9.8 \frac{\mathrm{~N}}{\mathrm{~kg}}\right) \\
& W_{1}=1470 \mathrm{~N} \\
& W_{1}=1500 \mathrm{~N}
\end{aligned}
$$

## Review Assessment: Lec 24 Quiz

| Name: | Lec 24 Quiz |
| :--- | :--- |
| Status : | Completed |
| Score: | 34 out of 100 points |

## Instructions:

## Question 1

0 of 17 points
An object is on the end of a horizontal ideal spring of spring constant $k$. The other end of the spring is attached to the wall. The object is on a frictionless horizontal surface. A person pulls the object directly away from the wall until the spring is stretched an amount x and releases the object from rest.

A student is asked to find the kinetic energy of the object when it first reaches that position at which the spring is neither stretched nor compressed. The student elects to use the work energy theorem which states that the work done on the object by the spring is equal to the change in kinetic energy of the object. The student reasons that the initial kinetic energy is zero. The change in kinetic energy is the final kinetic energy minus the initial kinetic energy. Because the latter is zero, the student reasons that the change in kinetic energy is the final kinetic energy. Thus the work energy theorem, for this special case boils down to the final kinetic energy being equal to the work done on the object by the spring. The student reasons that because the spring force, whose magnitude is $k x$, is acting in the same direction as the direction in which the object goes that the work done is just the work done is just the magnitude of the spring force times the distance that the object travels. Now, to get from the release point where the spring is stretched a distance $x$, to the equilibrium point where the spring is stretched a distance 0 , the student reasons that the object must travel a distance x . Hence, the student reasons that the work done must be kx times x or $\mathrm{kx}^{2}$ and therefore the kinetic energy of the object at the point in question must be $\mathrm{kx}{ }^{2}$. Is the student right? If not, what is wrong with the student's solution?

Selected $\quad \times$ The student is right.
Answer:
Correct $\quad \checkmark$ The student is wrong. The force only has magnitude $k x$ at the release point. As the object moves Answer:

## Question 2

An object is pulled along a frictionless horizontal surface by means of a string whose tension is 2.00 newtons. The string makes an angle of $25.0^{\circ}$ with the horizontal. Find the change in the kinetic energy of the object that occurs when it moves through a distance of .750 meters along the frictionless surface.

Selected Answer: $\downarrow 1.36 \mathrm{~J}$
Correct Answer: $\downarrow 1.36 \mathrm{~J}$
Feedback: Excellent. The change in the kinetic energy is equal to the work done on the object.



$$
\begin{aligned}
\frac{T_{x}}{T} & =\cos \theta \\
T_{x} & =T \cos \theta \\
& =2.00 \mathrm{~N} \cos 25.0^{\circ} \\
T_{x} & =1.813 \mathrm{~N}
\end{aligned}
$$



$$
\begin{aligned}
& W=\Delta K \\
& F_{11} d=\Delta K \\
& T_{x} d=\Delta K \\
& \Delta K=T_{x} d \\
& \Delta K=(1.813 N) .750 \mathrm{~m} \\
& \Delta K=1.36 \mathrm{~J}
\end{aligned}
$$

Question 3 an angle of $25.0^{\circ}$ with the horizontal. How much work is done by the string when the object moves a distance .750 meters along the surface?

Selected Answer: $\downarrow 1.36 \mathrm{~J}$
Correct Answer: $\checkmark 1.36 \mathrm{~J}$
Feedback: Well done.

$\frac{T_{x}}{T}=\cos \theta$

$$
\begin{aligned}
T_{x} & =T \cos \theta \\
& =2.00 \mathrm{~N} \cos 25.0^{\circ} \\
T_{x} & =1.813 \mathrm{~N}
\end{aligned}
$$



$$
W=\Delta K
$$

$$
W=F_{11} d
$$

$$
W=(1.813 \mathrm{~N}) .750 \mathrm{~m}
$$

$$
W=1.36 \mathrm{~J}
$$

Consider a problem in which an object is released from rest at a distance of one to two earth radii above the surface of the earth and one is asked to find the kinetic energy of the object as it enters the earth's atmosphere. One might think it pretty straight forward to solve (given values for the initial height of the object, the thickness of the
atmosphere, the radius of the earth, the mass of the earth, and the mass of the object) using the work energy theorem. The initial kinetic energy is zero so the final kinetic energy is equal to the change in kinetic energy. Thus the work energy theorem, which normally states that the work done on the object is equal to the change in kinetic energy, in this case states that the work done on the object is equal to its final kinetic energy. The problem lies in the difficulty in calculating the work done on the object by the gravitational force by direct application of definition of work. Why is that such a difficulty?

Selected $\times$ lt's not. The force is mg . Just multiply that by the distance from the release point to the surface Answer: of the atmosphere.

Correct $\checkmark$ The problem is that the magnitude of the force varies significantly along the path and therefore,
Answer: even though the force is in the direction of motion for the whole trip, one cannot calculate the work as simply force times distance.

Feedback: The closer the object is to the earth the stronger the force is. The force is different at different points along the path. To get the work done using the definition of work, one has to, in one's mind, break up the path into an infinite set of infinitesimal path segments. On each of these, because they are so short, the force has a definite value which depends on the distance of that particular path segment from the center of the earth. To get the infinitesimal amount of work done on such an infinitesimal path segment one just has to multiply the applicable force times the length of the path segment. After doing that for all the path segments one just has to add up all the resulting amounts of work. But that would be an infinite sum of infinitesimal amounts of work, in other words, an integral.

Note that the answer which treats the force as being equal to mg doesn't even come close to being okay here. Even if the object is released from the minimum height in the specified range, the object still starts out twice as far from the center of the earth as it would be at the earth's surface, meaning (because the Universal Law of Gravitation is an inverse square law) that the gravitational force on the object at the release point would be one fourth the gravitational force on the object when the object is at the surface of the earth.

## Question 5

0 of 16 points
Loosely speaking, work is defined as force times distance. According to the work energy theorem, the net work done on an object is equal to the change in kinetic energy. Does this mean that work is also defined as the change in kinetic energy?

Selected Answer: $\times$ Yes.
Correct Answer: $\downarrow$ No.
Feedback: The work energy theorem is a relation between cause and effect. Work is the cause and a change in kinetic energy is the effect. Work is not defined to be kinetic energy. Rather, a certain amount of work done on an object will cause a certain change in the kinetic energy of that object. The statement that work itself is, loosely speaking, force times distance, is however, nothing more than a definition.

## Question 6

0 of 16 points
The mnemonic for recalling what work is, states that "Work is force times distance." Under what conditions can the mnemonic be taken so literally that one can arrive at the correct answer for the work W done on an object by a force $\mathbf{F}$ when the object (consider the object to be a point object) travels a distance $d$ under the influence of said force simply by multiplying the magnitude of the force $F$ by the distance $d$ ?.

Selected $\quad \times$ Whenever the path is straight.
Answer:
Correct $\quad \checkmark$ Whenever the magnitude of the force is constant over the entire distance d traveled by the Answer: object and the force, over that same distance traveled, is at all points, tangent to the path and in the direction of motion of the object.

Feedback: The work is more specifically the component of the force along the path times the distance the object moves along the path. A straight path is not sufficient to make it so that $W=F d$ in that, if the force is not along the path the component of the force that is along the path will be smaller in magnitude then F so $W$ will be smaller in magnitude than Fd.

The force being constant is not sufficient for $W$ to be equal to Fd for a similar reason.
The force being in a constant direction, the path being straight, and the force lying along the same line or a parallel line as the one containing the path are not sufficient for $\mathrm{W}=\mathrm{Fd}$ in that if the force varies in magnitude there is no single value of the force along the path to plug in for F. Furthermore the stipulations don't rule out $F$ being in the direction opposite to that of the motion, in which case, if $F$ is constant, $\mathrm{W}=-\mathrm{Fd}$.

Note that the path does not have to be straight for W to be equal to Fd. As long as the force varies in direction as the object moves so that the force is always in the direction of motion it is possible for W to be equal to Fd. The additional stipulation for that to actually be the case is that the force be constant.

## Review Assessment: Lec 25 Quiz

| Name: | Lec 25 Quiz |
| :--- | :--- |
| Status : | Completed |
| Score: | 30 out of 100 points |

## Instructions

## Question 1

0 of 10 points
Folks who pay for their own electricity are billed according to the number of watt-hours they used during the billing period. Watt-hours are the units for what physical quantity?

Selected Answer: X Power
Correct Answer: $\checkmark$ Energy
Feedback: The watt is a unit of power (energy-per-time) and the hour is a unit of time so the watt-hour has to be a unit of energy. One can convert a watt-hour to joules quite easily. Recall that a watt is a $\mathrm{J} / \mathrm{s}$ and an hour is 3600 seconds. A watt-hour is thus $1 \mathrm{~J} / \mathrm{s}$ times 3600 s which is just 3600 J .

Consider a ring and a disk, each having the same mass and radius. Each is released from the same point at the top of a ramp. Each rolls, without slipping, to the bottom of the ramp and beyond. How does the forward velocity that the ring has, when it gets to the bottom of the ramp, compare with the forward velocity that the disk has, when it gets to the bottom of the ramp?

Selected Answer: $\times$ They both have the same forward velocity at the bottom of the ramp.
Correct Answer: $\checkmark$ The disk has a greater forward velocity at the bottom of the ramp.
Feedback: At the bottom, both objects have the same kinetic energy. In both cases the kinetic energy is partly energy of rotation and partly energy of translation (moving forward). The forward speed and the angular velocity for a given object that is rolling without slipping are always proportional to each other. The faster it goes forward the faster the object is spinning on its axis. If both objects were to have the same forward speed both objects would have the same spin rate. Both would have the same kinetic energy of translation but the ring would have the greater kinetic energy of rotation because it has the greater moment of inertia. So if both objects have the same speed, the ring has more kinetic energy.

But we know that both objects have the same kinetic energy at the bottom of the ramp. For the ring to have the same kinetic energy as the disk it must, therefore, be going slower than the disk.

For more information, click on the following link:
disk_and_ring.htm

## Question 3

10 of 10 points
Suppose that during the ascent of an elevator car, the power provided the elevator car by the elevator motor is 15000 watts. How much energy would be delivered to the elevator in 10 seconds?

Selected Answer: $\downarrow 150000$ Joules
Correct Answer: $\checkmark 150000$ Joules
Feedback: Nice work!
Power is the rate at which energy is being delivered to the elevator. It is measured in watts. A watt is a joule per second. So the total energy delivered is just the power times the time. In terms of units, the total number of joules is the number of joules per second times the number of seconds.

$$
\begin{aligned}
& E=P t \\
& E=(15000 \mathrm{~W}) \cdot(10 \mathrm{~s}) \\
& E=\left(15000 \frac{\mathrm{~J}}{\mathrm{~s}}\right) \cdot 10 \mathrm{~s} \\
& E=150000 \mathrm{~J}
\end{aligned}
$$

## Question 4

0 of 10 points
Consider a ring and a disk, each having the same mass and radius, and each spinning with the same angular velocity about its own axis of symmetry. Which, if either, has the greater kinetic energy?

Selected Answer: $\times$ Neither. They have one and the same value of kinetic energy.
Correct Answer: $\checkmark$ The ring has the greater kinetic energy.
Feedback: The kinetic energy of a spinning object is one half the product of its moment of inertia and the square of its angular velocity. Since both objects have the same angular velocity, the moment of inertia is the determining factor here. Both objects have the same mass but that mass is, in the case of the ring, distributed, on average, farther from the axis of rotation. Thus the ring has the greater moment of inertia. Therefore the ring has the greater kinetic energy.

## Question 5

10 of 10 points
Consider a ring and a disk, each having the same mass and radius. Each is released from the same point at the top of a ramp. Each rolls, without slipping, to the bottom of the ramp and beyond. How does the kinetic energy that the ring has, when it gets to the bottom of the ramp, compare with the kinetic energy that the disk has, when it gets to the bottom of the ramp.


Selected Answer: $\checkmark$ Both objects have one and the same value of kinetic energy at the bottom of the ramp.
Correct Answer: $\checkmark$ Both objects have one and the same value of kinetic energy at the bottom of the ramp.
Feedback: Nice job!
Both objects start from the same elevation and they have the same mass so they each start with the same amount of potential energy. On the way down the ramp, that potential energy is converted to kinetic energy. Since, at the bottom of the ramp, they are each at the same new elevation, the same amount of potential energy has been converted to kinetic energy.

## Question 6

0 of 10 points
What is power? (Indicate all that apply.)
Selected Answers: $\times$ Force per unit time.
Correct Answers: $\checkmark$ The rate at which work is done.
$\checkmark$ The rate at which energy is being delivered.
$\checkmark$ The rate at which energy is being used up.
$\checkmark$ The rate at which energy is being converted from one form to another.

Feedback: Power is the rate at which: work is done, energy is being delivered, energy is being used up, or energy is converted from one form to another. These are all pretty much the same thing but not quite. The definition applicable to a particular situation depends on the context.

A skater is spinning on ice. She pulls her arms and legs in so as to reduce her moment of inertia to one half its original value. How does this change her kinetic energy?

Selected Answer: $\times$ Her kinetic energy stays the same.
Correct Answer: $\checkmark$ Her kinetic energy increases.
Feedback: By conservation of angular momentum, the product of the skater's rotational inertia and her angular velocity, stays the same. Hence, by making her moment of inertia one half what it was, her angular velocity becomes twice what it was. Her kinetic energy is one half the product of her rotational inertia and the square of her angular velocity. Halving her rotational inertia introduces a factor of one half but the doubling of her angular velocity introduces a factor of 4 into the expression for her kinetic energy. $1 / 2$ times 4 is 2 , so her kinetic energy is two times what it was.

Where did this energy come from? It came from the skater. She had to do work to bring her arms and legs in.

## Question 8

0 of 10 points
The Calorie is a unit of energy. Some exercise machines provide the user with a value with units of Calories/minute. That value-with-units is a measure of what physical quantity?

Selected Answer: $X$ mass


Correct Answer: $\checkmark$ power
Feedback: Energy per time is power. In this case the exercise machine is telling the user the rate at which energy is being delivered to the exercise machine. This is very roughly equal to the rate at which the user is converting energy associated with the chemical bonds in food to mechanical energy. (Very roughly because an appreciable fraction of the energy associated with the chemical bonds in food is converted into thermal energy.)

## Question 9

10 of 10 points
What happens to the kinetic energy of a spinning rigid object if you make it spin twice as fast (e.g. by applying a torque to it for a certain time interval)?

Selected Answer: $\checkmark$ The kinetic energy becomes 4 times what it was.
Correct Answer: $\checkmark$ The kinetic energy becomes 4 times what it was.
Feedback: Way to go!
The kinetic energy is proportional to the square of the angular velocity, so, multiplying the angular velocity by a factor, results in a new kinetic energy equal to the square of that factor times the original kinetic energy. This assumes that the moment of inertia of the object does not change.

Question 10
0 of 10 points
A two-thousand-pound car accelerates uniformly from zero to sixty miles per hour in ten seconds. What is the average power of the car's engine during that ten-second time interval? (Note that a car whose weight is two thousand pounds has a mass of 908 kg . Also, sixty miles per hour is equivalent to $26.8 \mathrm{~m} / \mathrm{s}$.)

Selected Answer: $\times 5.00 \mathrm{~W}$
Correct Answer: $\checkmark 32.6$ kW
Feedback: The average power is just the change in kinetic energy divided by the time interval. The time interval is 10.0 seconds and the change in kinetic energy is determined as follows:

$$
\begin{aligned}
& \Delta K=K-K_{0} \\
& \Delta K=\frac{1}{2} m v^{2}-0 \\
& \Delta K=\frac{1}{2}(908 \mathrm{~kg})(26.8 \mathrm{~m} / \mathrm{s})^{2} \\
& \Delta K=326000 \mathrm{~J}
\end{aligned}
$$

Thus the power is given by:

$$
\begin{aligned}
& P=\frac{\Delta K}{\Delta t} \\
& P=\frac{326 \mathrm{~kW}}{10.0 \mathrm{~s}} \\
& P=32.6 \mathrm{~kW}
\end{aligned}
$$

Note that in the foot-pound-second (fps) system of units commonly used in the United States, the unit of power is the horsepower. One horsepower is equal to 746 watts so the average power of the car in question (during the ten-second time interval in question) is 43.7 horsepower.

## Review Assessment: Lec 26 Quiz

Name: Lec 26 Quiz

## Status : Completed

Score: 20 out of 100 points

## Instructions:

Question 1

## 0 of 20 points

Which of the following statements is most correct?


## Selected

$\times$ Force and Impulse each represent an ongoing process.
Answer:
Correct Answer: $\checkmark$ Force represents an ongoing process whereas impulse represents an event of limited duration.

## Question 2

0 of $\mathbf{2 0}$ points
By definition, impulse is:


Selected Answer: $X$ inertia.
Correct Answer: $\quad$ force times time.
Feedback: A change in momentum is the effect of an impulse, it is not the definition of impulse.

## Question 3

0 of 20 points
(Consider two objects confined to move along a straight line path. Consider to-the-right to be the positive direction. Suppose that the first object's momentum was $15 \mathrm{~kg} \cdot \mathrm{~m} / \mathrm{s}$ prior to it being struck by the second object and $4 \mathrm{~kg} \cdot \mathrm{~m} / \mathrm{s}$ afterward. What was the impulse delivered to the second object by the first? Except for the force exerted on each object by the other during the collision, assume that no forces act on either object.

Selected Answer: $\times$ The information given is insufficient to determine a definite answer.
Correct Answer: $\quad \checkmark$ No other answer provided is correct.

## Feedback:

BEFORE


AFTER


CHANGE IN MOMENTUM

$$
\begin{aligned}
& \Delta p_{1}=p_{1}^{\prime}-p_{1} \\
& \\
& =4 \mathrm{~kg} \cdot \frac{m}{s}-15 \mathrm{~kg} \cdot \frac{m}{s} \\
& \Delta p_{1}
\end{aligned}=-11 \mathrm{~kg} \cdot \frac{m}{s} .
$$

Object 1 has a mass of 1 kilogram.
Object 2 has a mass of 2 kilograms.
In a head-on collision of the two objects:
Selected
Answer:
Co object 1 by object 2 .
Correct
Answer:

Feedback: Nice work! While the directions of the two impulses are opposite, the magnitudes are the same. This follows from Newton's third law. During the time interval for which they act, the force that the first object exerts on the second is equal and opposite to the force that the second object exerts on the first. Multiply each force by one and the same time interval and you find that the impulses are equal in magnitude but opposite in direction too.

The impulse experienced by an object during a physical process is equal to:

Selected Answer: $\times$ the momentum of that object.
Correct Answer: $\checkmark$ the change in the momentum of that object.
Feedback: Note that the change in momentum is not an alternate definition for impulse. Impulse is defined as Force times Time. Its effect is to cause a change in momentum. Numerically, the change in momentum is equal to the impulse.

## Review Assessment: Lec 27 Quiz

Name: Lec 27 Quiz
Status: Completed
Score: 20 out of 100 points

## Instructions:

Question 1
On what physical characteristics of the mass-on-a-spring system does the period of oscillations of the mass depend? (Indicate all the correct answers.)

Selected Answers: $\times$ The length of the spring.
Correct Answers: $\checkmark$ The force constant of the spring.
$\checkmark$ The spring constant of the spring.
$\checkmark$ The mass of the object.

Feedback: Note that the force constant of the spring and the spring constant of the spring are two different expressions for the same thing, $k$, a quantity that characterizes how stiff the spring is.

The period of oscillations for a mass on a spring is given as

$$
T=2 \pi \sqrt{\frac{m}{k}}
$$

where $m$ is the mass of the object and $k$ is the force constant of the spring (also known as the spring constant).

Question 2
20 of 20 points
What happens to the frequency of oscillations if the spring is replaced with a stiffer spring?

Selected Answer: $\checkmark$ The frequency of oscillations increases.
Correct Answer: $\checkmark$ The frequency of oscillations increases.
Feedback: Way to go!
A stiffer spring is one having a higher spring constant (a.k.a.) force constant, and, the bigger the spring constant, the greater the frequency of oscillations.

You should be able to arrive at the correct answer by visualizing the situation. The stiffer the spring the more rapidly the mass will snap back toward its equilibrium position. Upon overshooting the equilibrium position the stiffer spring will bring the object to rest more quickly. the process repeats ad nauseam, with the stiffer spring making each oscillation happen more quickly resulting in a higher frequency of oscillations.

What happens to the frequency of oscillations of a mass on a spring if the spring is replaced with a spring having twice the force constant as compared to that of the original spring?

Selected Answer: $\times$ It becomes half what it was.
Correct Answer: $\quad \checkmark$ It becomes the square root of two times what it was.

Feedback:

[^0]The frequency of oscillations for a mass on a spring is given by

$$
f=\frac{1}{2 \pi} \sqrt{\frac{k}{m}}
$$

Doubling $k$ introduces a factor of two in the numerator inside the square root. This corresponds to an overall factor of the square root of two.

One way to show the work for this would be to let $k^{\prime}=2 k$ be the new spring constant and $f^{\prime}$ be the new frequency. Then:
$f^{\prime}=\frac{1}{2 \pi} \sqrt{\frac{k^{\prime}}{m}}$
$f^{\prime}=\frac{1}{2 \pi} \sqrt{\frac{2 k}{m}}$
$f^{\prime}=\sqrt{2} \frac{1}{2 \pi} \sqrt{\frac{k}{m}}$
$f^{\prime}=\sqrt{2} f$
Some folks prefer to find the ratio $\frac{f^{\prime}}{f}$ as follows (again defining $f^{\prime}$ as the new frequency and $k^{\prime}=2 k$ as the new spring constant):

As before, $f=\frac{1}{2 \pi} \sqrt{\frac{k}{m}}$ and $f^{\prime}=\frac{1}{2 \pi} \sqrt{\frac{k^{\prime}}{m}}=\frac{1}{2 \pi} \sqrt{\frac{2 k}{m}}$ so
$\frac{f^{\prime}}{f}=\frac{\frac{1}{2 \pi} \sqrt{\frac{2 k}{m}}}{\frac{1}{2 \pi} \sqrt{\frac{k}{m}}}$
$\frac{f^{\prime}}{f}=\sqrt{2}$
Finally, multiplying both sides by $f$ we find that

$$
f^{\prime}=\sqrt{2} f
$$

Suppose that for a mass $m$ undergoing simple harmonic motion on the end of a spring with force constant $k$, the maximum stretch of the spring is A. What is the total energy of the system when the spring is stretched an amount $1 / 2 \mathrm{~A}$ ?

## Selected Answer: $\times 0$

Correct Answer: $\quad 1 / 2 k A^{2}$
Feedback: Based on the wording of the question $m$, $k$, and $A$ are to be considered known. The total energy at any instant during the motion of the mass is the sum of the kinetic energy of the mass and the potential energy stored in the spring. Furthermore, the total energy always has the same value. The energy is shared differently between the kinetic energy and the potential energy, but it always has the same total value. At maximum stretch the kinetic energy is zero so the total energy is just the potential energy $1 / 2 k A^{2}$. At the position in question, the mass is moving and the spring is somewhat stretched so there is some kinetic energy and some potential energy but the total energy is the same as it was before. That is, total energy is still $1 / 2 k A^{2}$.

## Question 5

0 of $\mathbf{2 0}$ points
Suppose that for a mass $m$ undergoing simple harmonic motion on the end of a spring with force constant $k$, the maximum stretch of the spring is $A$. What is the kinetic energy of the system when the spring is stretched an amount $1 / 2 A$ ?

## Selected Answer: $\times 0$

Correct Answer:

$$
3 / 8 \mathrm{kA}^{2}
$$

Feedback: Based on the wording of the question $m, k$, and $A$ are to be considered known. The total energy at any instant during the motion of the mass is the sum of the kinetic energy of the mass and the potential energy stored in the spring. Furthermore, the total energy always has the same value. The energy is shared differently between the kinetic energy and the potential energy, but it always has the same total value. At maximum stretch the kinetic energy is zero so the total energy is just the potential energy $1 / 2 k A^{2}$. At the position in question, the mass is moving and the spring is somewhat stretched so there is some kinetic energy and some potential energy but the total energy is the same as it was before.
$\mathrm{E}=\mathrm{K}+\mathrm{U}$
$\frac{1}{2} \mathrm{kA}^{2}=\mathrm{K}+\frac{1}{2} \mathrm{kx}^{2}$
but $x$ is given as $\frac{1}{2} A$ so
$\frac{1}{2} k A^{2}=K+\frac{1}{2} k\left(\frac{1}{2} A\right)^{2}$
$\frac{1}{2} \mathrm{kA}^{2}=\mathrm{K}+\frac{1}{8} \mathrm{kA}^{2}$
$\mathrm{K}=\frac{3}{8} \mathrm{kA}^{2}$

## Review Assessment: Lec 28 Quiz

Name: Lec 28 Quiz
Status: Completed
Score: $\quad 25$ out of 100 points

## Instructions:

0 of 25 points
As regards the simple pendulum, what is meant by the expression "period of oscillation?"

Selected Answer: $\times$ The time that it takes for the oscillations of the pendulum to die out.
Correct Answer: $\checkmark$ The time it takes for the pendulum to complete one entire oscillation, back and forth.
Feedback: Note that the time from when the bob is at its lowest point until the next instant that it is at its lowest point is only half a period. Starting at its lowest position, the bob has to go all the way up on one side, back down to the lowest position, all the way up on the other side, and finally back down to the lowest position again in order to complete one full cycle of the motion. You can tell that it has not returned to the same point in its repetitive motion when it reaches the bottom the first time after the start of observations (starting the observations when the bob is at its lowest point) because at that instant, the bob's velocity is in the opposite direction to its velocity at the start of observations.

Question 2
0 of 25 points
On what physical characteristics of the simple pendulum does the period of oscillations of the pendulum depend? (Indicate every answer that is correct.)

Selected Answers: $\checkmark$ The length of the pendulum.

Correct Answers: $\checkmark$ The length of the pendulum.
$\checkmark$ The gravitational force constant $g$.

## Feedback:

The period $T$ of a simple pendulum is given as:

$$
T=2 \pi \sqrt{\frac{L}{g}}
$$

where $g$ is the earth's near-surface gravitational force constant $9.8 \mathrm{~N} / \mathrm{kg}$ and $L$ is the length of the simple pendulum.

## Question 3

0 of 25 points
The bob of a simple pendulum is gently pulled to one side in such a manner that the string remains straight. The bob is released from rest at an elevation that is $h$ greater than the bob's lowest possible position. The bob has mass $m$. The pendulum is at the surface of the planet earth. Subsequent to the release of the bob, what is the kinetic energy of the pendulum when the bob is at its lowest point?

Selected Answer: $\times 0$
Correct Answer: $\checkmark \mathrm{mgh}$
Feedback: Certainly the kinetic energy can always be expressed as $1 / 2 m v^{2}$ but $v$ is not given. Based on the wording of the question we are supposed to consider $h$ and $m$ to be known/given quantities. The nearearth gravitational force constant $g$ is also known. We are supposed to express the answer in terms of
known quantities. Since $v$ is unknown, $1 / 2 m v^{2}$ is not an acceptable answer.
Upon release, the bob has no velocity so it has no kinetic energy. Choosing the reference level to be the lowest level of the bob, at the release point the total energy is just the potential energy mgh. While we have to leave it in the form mgh because actual values are not provided, it is important to note that this is just some number of joules of energy. Based on the principle of conservation of energy, the pendulum bob will always have this total amount of energy. At the lowest point in its motion, the bob has no potential energy thus the total energy is just the kinetic energy. Turning this statement around, the kinetic energy is equal to the total energy (which we found to be mgh).

## Question 4

Where, in the motion of the bob of a simple pendulum, will the bob have its greatest speed?

Selected Answer: $\checkmark$ At the lowest point in its motion.
Correct Answer: $\checkmark$ At the lowest point in its motion.
Feedback: Excellent!
At the highest point in the motion of the pendulum bob, the energy is all potential. In between the highest and lowest points in its motion, the energy is a combination of potential energy and kinetic energy. At the bottom, it is all kinetic energy. But the total amount of energy is always the same. Thus, when it is all kinetic energy, that is when the bob is at the lowest point in its motion, the kinetic energy, being equal to the total energy, is at its greatest value. Kinetic energy is energy of motion. Where it is greatest, the speed of the bob is greatest.

## Review Assessment: Lec 29 Quiz

| Name: | Lec 29 Quiz |
| :--- | :--- |
| Status : | Completed |
| Score: | 35 out of 100 points |

## Instructions

## Question 1

0 of 15 points
Consider a segment of a long length of string through which a wave is traveling. The wave is produced by a continuously oscillating source. Within that segment there is a certain amount of wave energy. As long as the amplitude of the oscillations remains the same, the amount of wave energy in that segment of the string always has the same value. Now suppose that the amplitude of the oscillations producing the wave is doubled so the wave amplitude in the segment of the string in question is doubled. How does the wave energy in that segment of the string compare with the original wave energy in that segment of the string?

Selected Answer: $\times$ The new wave energy in the segment is one fourth the original wave energy.
Correct Answer: $\quad$ The new wave energy in the segment is four times the original wave energy.
Feedback: The wave energy is proportional to the square of the amplitude of the wave. So, if we double the amplitude, we enter a factor of two squared, that is 4 , into the expression for the energy of the wave in terms of the amplitude.

## Question 2

15 of 15 points
What's the difference between longitudinal waves and transverse waves?

Selected $\checkmark$ In the case of longitudinal waves, the particles in the medium in which the wave is traveling
Answer: oscillate back and forth along the path of the wave; whereas; in the case of transverse waves, the particles oscillate back and forth (or up and down) at right angles to the path of the wave.


Correct $\quad \checkmark$ In the case of longitudinal waves, the particles in the medium in which the wave is traveling
Answer: oscillate back and forth along the path of the wave; whereas; in the case of transverse waves, the particles oscillate back and forth (or up and down) at right angles to the path of the wave.

Feedback: Nice job!
Transverse means perpendicular. So transverse waves are waves in which the oscillations take place at right angles to (transverse to, perpendicular to) the direction of wave travel.

## Question 3

0 of 15 points
Consider sound from a point source in air. Assume that the absorption of sound energy by the air is negligible and that there are no obstacles to the sound waves. Further consider two points in the air. Point B is twice as far from the source as point $A$ is. How does the intensity of sound at point $B$ compare with the intensity of sound at point $A$ ?

Selected Answer: $X$ The intensity at $B$ is $2 d B$ less than the intensity at $A$.
Correct Answer: $\checkmark$ The intensity at B is one fourth the intensity at A .
Feedback: The intensity is proportional to the reciprocal of the square of the distance from the source. Thus, doubling the distance from the source introduces an extra factor of two squared in the denominator of the expression for the intensity as a function of the power of the source and the distance from the source. This corresponds to an overall factor of $1 / 4$.
the graphs as applicable, the peak-to-peak amplitude of the motion. Which of the following would correspond to the correct answer? (Indicate every correct answer.)

Selected Answers: X The horizontal distance between peaks on the Displacement vs. Time graph.
Correct Answers: $\checkmark$ The vertical distance between peaks on the Displacement vs. Time graph.
$\checkmark$ The vertical distance between peaks on the Displacement vs. Position graph.

Feedback: The amplitude is the maximum value of the displacement. The peak-to-peak amplitude is the distance from the position of maximum negative displacement to the position of maximum positive displacement. On a graph, it is measured along the displacement axis. In both graphs under consideration here, the displacement is plotted on the $y$-axis (the vertical axis.) So the peak-to-peak amplitude can be indicated on either graph. In both cases, because displacement is plotted along the vertical axis, the peak-to-peak amplitude is indicated as the vertical distance between peaks.


Suppose that for a string undergoing traveling wave motion you were asked to sketch a graph of Displacement vs. Position and a graph of Displacement vs. Time. Further suppose that you were asked to indicate, on one or both of the graphs as applicable, the period of the motion. Which of the following would correspond to the correct answer? (Indicate every correct answer.)

Selected Answers: $\downarrow$ The horizontal distance between peaks on the displacement vs. time graph.
Correct Answers: $\checkmark$ The horizontal distance between peaks on the displacement vs. time graph.

Feedback: Nice work!
The period is the time it takes for a given point in the medium to complete one full oscillation. Because
the period is an amount of time, it can only be indicated on the Displacement vs. Time graph. Because time is plotted along the x-axis (the horizontal axis) the period is measured along the horizontal axis. One period is indicated as extending horizontally on the graph from one point on the curve to the next point at which the slope of the curve and the displacement have the same values as the slope and displacement at the first point respectively. A convenient starting point is at a positive peak value in which case one can indicate the period as extending from the top dead center of one peak to the top dead center of the next.


## Question 6

0 of 15 points
A sound source is delivering sound energy to the air, uniformly in all directions, at the rate of 25 watts. What is the intensity of the sound from that source at a distance of 18 meters from the source? (Assume the absorption of sound by the air to be negligible. Assume there are no obstacles in the path of the sound. Treat the sound source as a point source.)

Selected Answer: $\times 1.39 \mathrm{~W} / \mathrm{m}$
Correct Answer: $\checkmark 6.14 \mathrm{~mW} / \mathrm{m}^{2}$
Feedback: All the energy produced by the source has to pass through a spherical shell of radius 18.0 m centered on the source. Thus, the rate at which energy is being delivered to the air by the source is the same as the rate at which it passes through such a spherical shell. Based on the symmetry of the configuration, the intensity at all points on the spherical shell has one and the same value--the value sought in this problem. The intensity is the power per area. Thus, to get the intensity at 18.0 m , we just have to divide the power of the source (the rate at which the source is delivering energy to the air and thus the rate at which energy is passing through the spherical shell) by the area of the spherical shell. Now the area of a spherical surface is just $4 \pi$ times the square of its radius $r$. So the intensity $I$ at a distance of 18.0 m from a point source of power $P$ is:

$$
\begin{aligned}
& I=\frac{P}{4 \pi r^{2}} \\
& I=\frac{25.0 \mathrm{~W}}{4 \pi\left(18.0 \mathrm{~m}^{2}\right)} \\
& I=.00614 \frac{\mathrm{~W}}{\mathrm{~m}^{2}} \\
& I=6.14 \frac{\mathrm{~mW}}{\mathrm{~m}^{2}}
\end{aligned}
$$

## Review Assessment: Lec 30 Quiz

Name: Lec 30 Quiz

Status : Completed
Score: 19 out of 100 points

## Instructions:

Question 1
0 of 19 points
Depicted is an idealized configuration of a string for the case in which two waves are traveling toward each other. Which of the following best represents the idealized configuration of the string, one second later?


Selected Answer: X


Correct Answer:


Feedback: One second later the wave on the left will have moved rightward by 3.0 cm and the one on the right will have moved leftward by 3.0 cm so parts from the respective waves that are 6.0 cm apart to start with will be right on "top of each other" one second later. The original diagram is redrawn here with a pair of parts initially separated by 6.0 cm indicated, just to make it easier to see how the waves will interfere one second later.


Now if each wave was on its own string, after a second the strings would look like this:

but of course they are both on the same string, so, at each position along the string, we have to add the string displacement due to one wave to the string displacement due to the other wave. This yields:

which is the answer.

In the case of standing waves in a string that is fixed at both ends, what is the difference between "the fundamental" and "the first harmonic?"

Selected $\quad \times$ The fundamental represents the longest wavelength standing wave that can exist in the device Answer: under consideration whereas the first harmonic represents the second longest wavelength.
Correct $\quad \checkmark$ There is no difference. They are two different names for the same thing.
Answer:
Feedback: The two expressions represent the two different naming schemes for the standing waves that can exist in a finite length. In one scheme the longest wavelength is called the fundamental, the second longest wavelength the 1st overtone, the third longest the 2nd overtone, etc. In the other scheme it goes: 1st harmonic (for the longest wavelength possible), 2nd harmonic, 3rd harmonic, etc.

There is a difference in the case of standing waves in a string that is fixed at one end and free at the other. The frequencies of harmonics, are always integer multiples of the fundamental, and, by convention, the number of the harmonic is named for the corresponding multiple. In the case of standing waves in a string that is fixed at one end and free at the other, the frequency of the first overtone is 3 times that of the fundamental. So, the first overtone is called the 3rd harmonic. There is no second harmonic. In fact, there are no even harmonics at all. The second overtone is the 5th harmonic, the third overtone is the 7th harmonic, etc.

Indicate the way or ways that standing waves differ from traveling waves. (Indicate all that apply.)

Selected $\quad \times$ In standing waves the particles, of the medium, that take part in the wave motion just oscillate Answers: back and forth about their equilibrium positions whereas in traveling waves, the particles oscillate and travel in the direction in which the wave is traveling.

## Correct $\quad \checkmark$ Standing waves are the result of interference, traveling waves are not. <br> Answers: $\quad$ Standing waves have nodes, traveling waves do not have nodes. <br> $\checkmark$ Standing waves always involve wave reflection, traveling waves do not.

Feedback: Standing waves exist in media which have limits. ("Media" is the plural of "medium" which in this context is the material or substance in which the wave exists. Another way of putting this would be to say that the medium is the stuff that is "waving".) We call the limits the ends of the medium. In the case of standing waves, a wave traveling in one direction reflects off one end of the medium and travels in the opposite direction until it gets to the other end. It reflects off the other end so that it is again traveling in the original direction. The process continually repeats. Standing waves result from the continual interference of the wave traveling in one direction with the wave traveling in the opposite direction.

Nodes represent bits of matter in the medium that never move from their equilibrium positions even though the waves travel through them. They are at positions in the medium at which the interference is always destructive. Only standing waves have nodes. At any instant in time there are bits of matter, in that part of the medium through which a traveling wave is moving, which are at their equilibrium positions, but as time goes by, such points will move away from their equilibrium positions. Hence, such points are not nodes.

## Question 4

## 0 of 19 points

The wave function below characterizes a wave moving in what direction?
$y=(.210 \mathrm{~m}) \cos \left[\left(5.82 \frac{\mathrm{rdd}}{\mathrm{m}}\right) x+\left(94.2 \frac{\mathrm{rd}}{\mathrm{s}}\right) t\right]$

Selected Answer: $\times$ The positive $x$ direction.
Correct Answer: $\checkmark$ The negative $x$ direction.
Feedback: Suppose you are watching a wave in a string. Suppose you focus your attention on one point on the wave, say the peak of a crest. The speed with which you see that point moving is the wave speed. The thing about that point that makes it so that you can keep track of it, is that it always has the same displacement. Now look at the wave function

$$
y=(.210 \mathrm{~m}) \cos \left[\left(5.82 \frac{\mathrm{rd}}{\mathrm{~m}}\right) x+\left(94.2 \frac{\mathrm{nd}}{\mathrm{~s}}\right) t\right]
$$

In order to keep the value of $y$ (the displacement) the same as time goes by (t gets larger), the argument of the cosine (that which you are taking the cosine of) has to remain the same. For the argument of the cosine

$$
\left[\left(5.82 \frac{\mathrm{rdd}}{\mathrm{~m}}\right) x+\left(94.2 \frac{\mathrm{rd}}{\mathrm{~s}}\right) t\right]
$$

to remain the same as $t$ gets bigger $x$ must get smaller. Now $x$ is the position of the point on the wave upon which your attention is focused. If that point's $x$ value is getting smaller as time goes by then the point, and hence the wave, must be traveling in the negative $x$ direction.

For the wave characterized by the wave function below, what is the frequency of the wave?
$y=(.210 \mathrm{~m}) \cos \left[\left(5.82 \frac{\mathrm{rdd}}{\mathrm{m}}\right) x+\left(94.2 \frac{\mathrm{rd}}{\mathrm{s}}\right) t\right]$


Selected Answer: $\checkmark 15.0 \mathrm{~Hz}$
Correct Answer: $\checkmark 15.0 \mathrm{~Hz}$
Feedback: Nice work!
That which is multiplying the time variable $t$ in the wave function

$$
y=(.210 \mathrm{~m}) \cos \left[\left(5.82 \frac{\mathrm{xdd}}{\mathrm{~m}}\right) x+\left(94.2 \frac{\mathrm{nd}}{\mathrm{~s}}\right) t\right]
$$

is $2 \pi$ divided by the period. But the reciprocal of the period is the frequency, so, that which is multiplying t in the wave function is $2 \pi$ times the frequency:

$$
94.2 \mathrm{rad} / \mathrm{s}=2 \pi \mathrm{f}
$$

Solving for $f$ we find that

$$
\mathrm{f}=15.0 \mathrm{~Hz}
$$

## Review Assessment: Lec 31

Name: Lec 31

Status : Completed
Score: 40 out of 100 points
Instructions:

Question 1
0 of $\mathbf{2 0}$ points
What is the wavelength of the first overtone of a 60.0 cm pipe which is closed at one end and open at the other?

Selected Answer: X 45.0 cm
Correct Answer: $\checkmark$ No other answer provided is correct.
Feedback:


## Fundamental



$$
\begin{aligned}
\frac{3}{4} \pi & =L \\
\lambda & =\frac{4}{3} L \\
\lambda & =\frac{4}{3} 60.0 \mathrm{~cm} \\
\lambda & =80.0 \mathrm{~cm}
\end{aligned}
$$

How many interior nodes (nodes not at the endpoints) does the first harmonic in a tube, in air, that is open at one end and closed at the other, have?

Selected Answer: $\checkmark 0$

## Correct Answer: $\quad 0$

Feedback: Well done!


There is a node at an endpoint but in this question we are asked for the number of interior nodes (not the total number of nodes) and there are no interior nodes.

## Question 3

0 of 20 points
How many nodes (total number of nodes) does the first overtone of a string, fixed at both ends, have?

## Selected Answer: $\times 0$

Correct Answer: $\downarrow 3$
Feedback:


In this question we are asked for the total number of nodes, including endpoint nodes. The first overtone (also known as the second harmonic) has one interior node as well as a node at each of the two endpoints. Thus, it has a total of three nodes.

A violin string carries a standing wave of known frequency and wavelength. Because the string is waving in air it produces sound waves in the air. Which of the following characteristics of the wave in air is (or are) necessarily the same as the corresponding characteristic (or characteristics) of the wave in the violin string? Choose all that apply.

Selected Answers: $\checkmark$ frequency
Correct Answers: $\checkmark$ frequency

Feedback: Well done!
In the case of a standing wave of one frequency in a violin string, all the points in the violin string that are oscillating, that is, all the points in the violin string except for those at the nodes, are oscillating back and forth at the same frequency, namely the frequency of the standing wave.

Consider any short segment of the violin string. As that string segment moves forth it pushes the air molecules in front of it forward creating a region behind the string segment that would be a vacuum except that the air molecules that were behind the string are pushed into that region by the surrounding air. As the string segment moves back it pushes the air molecules behind the string segment backward creating a region in front of the string segment that would be a vacuum except that the air molecules in front of the string are pushed into that region by the surrounding air. The process continually repeats. The air molecules in contact with the string thus move back and forth in concert with the string. Every time the string moves forth the air molecules in contact with the string are
forced to move forth. And every time the string moves back the air molecules in contact with the string are forced to move back. Thus the frequency with which the air molecules move back and forth is the same as the frequency with which the segment of the violin string is moving back and forth. And therefore, the frequency of the sound wave in air is identical to the frequency of the standing wave in the string.

This can be more simply expressed in terms of the cause of waves. What causes a wave is something oscillating. The frequency of a wave is the same as the frequency of the oscillations that are causing the wave. In this case the violin string, oscillating at the frequency of the standing wave in it, causes the sound wave in the air. Thus the frequency of the sound wave in air is identical to the frequency of the standing wave in the string.

## Question 5

0 of 20 points
How does the frequency of the third harmonic in a pipe compare with the frequency of the third harmonic in a pipe that is twice as long as the first pipe but has the same end-cap configuration as the first pipe?

Selected $\quad \times$ The frequency of the third harmonic in the longer pipe is one fourth the frequency of the third Answer: harmonic in the shorter pipe.

Correct $\checkmark$ The frequency of the third harmonic in the longer pipe is one half the frequency of the third Answer: harmonic in the shorter pipe.
Feedback: The wavelength of any given harmonic is going to be some constant times the length of the pipe. (Another way of saying this is to say that the wavelength is proportional to the length of the pipe.) Thus if one doubles the length of the pipe, the wavelength is doubled.

Now consider the expression $v=\lambda f$ for the wave velocity. The wave velocity in this case is the speed of sound in air which does not depend on the length of a pipe. Hence, $v$ is the same for both cases. Solving for $f$ we find that $f=v / \lambda$. That is, the frequency is proportional to the reciprocal of the wavelength. Thus, doubling the wavelength results in the halving of the frequency.

$$
\begin{aligned}
& \lambda=\text { const } \cdot L \\
& \lambda^{\prime}=\text { const } \cdot L^{\prime} \\
& L^{\prime}=2 L \\
& \lambda^{\prime}=\text { const } \cdot 2 L \\
& \lambda^{\prime}=2 \cdot \text { const } \cdot L \\
& \lambda^{\prime}=2 \lambda \\
& \mathrm{v}=\lambda \mathrm{f} \\
& \mathrm{f}=\frac{\mathrm{v}}{\lambda} \\
& \mathrm{f}^{\prime}=\frac{\mathrm{v}}{\lambda^{\prime}} \\
& \mathrm{f}^{\prime}=\frac{\mathrm{v}}{2 \lambda} \\
& \mathrm{f}^{\prime}=\frac{1}{2} \frac{\mathrm{v}}{\lambda} \\
& \mathrm{f}^{\prime}=\frac{1}{2} \mathrm{f}
\end{aligned}
$$

## Review Assessment: Lec 32 Quiz

| Name: | Lec 32 Quiz |
| :--- | :--- |
| Status : | Completed |
| Score: | 20 out of 100 points |

## Instructions:

## Question 1

## 0 of $\mathbf{2 0}$ points

A sound source of 455.0 Hz and a second sound single-frequency source produce beats at 5.0 Hz . What is the frequency of the second sound source? Choose the MOST correct answer.

Selected $\quad \times 450.0 \mathrm{~Hz}$
Answer:
Correct Answer: $\checkmark$ Either 450.0 Hz or 460.0 Hz . Not enough information is provided to distinguish between these two cases.

Feedback: The beat frequency is equal to the absolute value of the difference between the two frequencies of the waves that are interfering with each other. But there are two correct answers to the question "what frequency differs from 455.0 Hz by 5.0 Hz ?" 460.0 Hz is 5.0 Hz higher than 455.0 Hz and 450.0 Hz is 5.0 Hz lower than 455.0 Hz . In both cases the absolute value of the difference is 5.0 Hz . Each answer is equally good. Either, in concert with the 455.0 Hz wave, would produce beats with a frequency of 5.0 Hz . With no further information, there is no way to distinguish one of the two frequencies as being the better answer.

Consider a single-frequency sound source moving toward a person through still air. What determines the loudness of the sound heard by the person? (Choose the one BEST answer.)

Selected Answer: $\times$ The power of the source alone.
Correct Answer: $\checkmark$ Both the power of the source and the distance of the source from the person.
Feedback: The Doppler effect has nothing to do with loudness. Trust your common sense as regards loudness. The louder the source (that is, the more power the source is putting out), the louder the observed sound. And, the closer the source (to the observer), the louder the observed sound.

## Question 3

20 of 20 points
Consider two stationary sound sources of the same power and a stationary listener. One of the sources produces sound at 264 Hz and the other at 262 Hz . What is the beat frequency? Choose the MOST correct answer.


Selected Answer: $\checkmark 2 \mathrm{~Hz}$
Correct Answer: $\checkmark 2 \mathrm{~Hz}$
Feedback: Excellent!
The beat frequency is simply the absolute value of difference between the two source frequencies.

Suppose that you are on the platform at a train station as an express train approaches the station. The train does not stop at that station but for safety reasons it must slow down to 30 mph before it gets to the station. When you first hear the train, it is going at 102 mph and slowing down. The train whistle is sounding. The train whistle itself is oscillating at a fixed frequency and delivering sound to the air at a fixed power. As the train approaches the station, what do you observe about the sound you hear coming from the train whistle (besides the fact that it is getting louder)?

Selected $\quad \times$ The frequency is lower than the frequency of oscillations of the whistle, and it is getting Answer: lower.

Correct Answer: $\checkmark$ The frequency is higher than the frequency of oscillations of the whistle, and it is getting lower.

Feedback: On first learning about the Doppler effect, many people get the mistaken impression that it's position that matters rather than velocity. They'll hear, for instance, that because the source has a velocity directed toward the observer, the observer will receive a higher frequency; but they'll incorrectly interpret that to mean that because the source is getting closer to the observer, the frequency received by the observer is increasing. That is not at all the case. If the source is approaching the receiver at a constant speed, then the frequency received by the receiver is higher than the frequency of the oscillations of the source, but it is not getting higher. The received frequency is at one fixed value that is higher than the frequency of the source as long as the source is approaching at constant speed. It is the speed of approach that matters, not how close the source is. In fact, as in the question at hand, if the source is approaching at a decreasing speed, the received frequency (though always higher than the frequency of the source) is actually decreasing.

Note that frequency is pitch, not loudness. Trust your common sense as regards loudness. The closer the source is, the louder it sounds. In the case of loudness, it is position that matters.

Consider a single-frequency sound source moving toward a stationary person through still air. What determines the frequency of the sound heard by the person? (Choose the one BEST answer.)

Selected Answer: $\times$ The frequency of the source alone.
Correct Answer: $\checkmark$ Both the frequency of the source and the speed of the source.
Feedback: In accord with the Doppler effect, the faster the source is moving toward the receiver, the higher the observed frequency. But the observed frequency is always some number (determined by the velocity of the source and the speed of sound) times the frequency of oscillations of the source. So, considering the speed of sound in air as a given, for the case of a stationary receiver, the observed frequency is determined by both the speed of approach of the source and the frequency of oscillations of the source.

## Review Assessment: Lec 33 Quiz

| Name: | Lec 33 Quiz |
| :--- | :--- |
| Status : | Completed |
| Score: | 30 out of 100 points |

## Instructions:

## Question 1

10 of 10 points
According to Archimedes' Principle:

| Selected <br> Answer:The buoyant force exerted by a fluid on an object that is either partly submerged or totally <br> submerged in that fluid is equal in magnitude to the weight of the fluid that would be where the <br> object is if the object wasn't there. |  |
| :--- | :--- |
| Correct | The buoyant force exerted by a fluid on an object that is either partly submerged or totally |
| submerged in that fluid is equal in magnitude to the weight of the fluid that would be where the |  |
| object is if the object wasn't there. |  |

Feedback: Way to go!

## Question 2

0 of 10 points
Match the physical quantities with the definitions.

| Question pressure | Correct Match <br> $\checkmark$ E. A measure of force-magnitude-per-area. |
| :---: | :---: |
| volume | $\checkmark$ F. A characteristic of an entity indicating how much space the entity occupies in the universe. |
| density | $\checkmark$ D. A characteristic of any particular kind of matter that indicates the mass-per-volume of that substance. |
| mass | $\checkmark$ B. A characteristic of an object or quantity of matter that indicates the degree to which that object resists a change in its velocity. |
| area | $\checkmark$ C. A measure of amount of surface. |

## Selected Match

$\times \mathrm{A}$. That characteristic of an object or quantity of matter that indicates how hard the earth is pulling that object toward its center.
$\times \mathrm{A}$. That characteristic of an object or quantity of matter that indicates how hard the earth is pulling that object toward its center.
$\times \mathrm{A}$. That characteristic of an object or quantity of matter that indicates how hard the earth is pulling that object toward its center.
$\times \mathrm{A}$. That characteristic of an object or quantity of matter that indicates how hard the earth is pulling that object toward its center.
$\times \mathrm{A}$. That characteristic of an object or quantity of matter that indicates how hard the earth is pulling that object toward its center.

## Question 3

0 of 10 points
A bowling ball is released from rest from a position in a swimming pool where the ball is totally submerged in water.
The bowling ball sinks. Why does it sink?
Selected Answer: X The water is more dense than the ball.
Correct Answer: $\checkmark$ The downward weight of the ball exceeds the upward buoyant force on the ball.

A boat floats at rest on still water. How does the buoyant force compare, in magnitude, with the weight of the boat?

Selected Answer: $\checkmark$ The buoyant force is equal, in magnitude, to the weight of the boat.
Correct Answer: $\checkmark$ The buoyant force is equal, in magnitude, to the weight of the boat.
Feedback: Nice work!
For the boat to continually be at rest, the net force on it must equal zero. The only vertical forces acting on the boat are the weight force and the buoyant force. These are in opposite directions. For them to add up to zero they must be equal in magnitude.

## Question 5

0 of 10 points
A child is in a boat with a rock in it, in a backyard swimming pool. The child removes the rock from the boat and drops it into the water. It sinks to the bottom. What happens to the water level in the pool.

Selected Answer: $\times$ It stays the same.
Correct Answer: $\checkmark$ It goes down.
Feedback: While the rock is in the boat, the buoyant force is equal to the weight of the boat-and-child plus the weight of the rock. Once the rock is in the water, the buoyant force is less than this because, while it is still supporting the boat and the child, the water is no longer supporting the rock. If the buoyant force is smaller when the rock is in the water, then the weight of the displaced water must be less when the rock is in the water, since, by Archimedes' Principle, the buoyant force is equal in magnitude to the weight of the displaced water. This means that the items in the water are taking up less room in the water, hence, the top surface of the water is lower (closer to the bottom of the pool) when the rock is in the water.

## Question 6

0 of 10 points
A person totally submerges a cork in water and releases it from rest. There is an upward buoyant force on the cork. What is the agent of that force? (The agent of a force on an object is the thing, the creature, or the stuff that is pushing or pulling on the object.)

Selected Answer: $\times$ Pressure.
Correct Answer: $\checkmark$ The water.
Feedback: The water is the only agent in the list. Pressure is a characteristic of fluids, gravity is a kind of a force, and density is another characteristic of fluids. None of these can be the agent of a force. The water is indeed the agent of the force. It pushes upward on the bottom of the cork harder than it pushes downward on the top of the cork. This is because the bottom of the cork is at a greater depth in the water than the top of the cork is. The greater the depth, the greater the pressure of the water. The greater the pressure, the greater the force with which the water pushes on a given area of the cork. The result is a net upward force called the buoyant force.

## Question 7

10 of 10 points
How does the weight of an object in vacuum compare with the weight of the same object in water?
Selected Answer: $\checkmark$ They are both the same.
Correct Answer: $\checkmark$ They are both the same.
Feedback: Nice job.
The weight of the object is how hard the earth is pulling on the object. That doesn't change when you put the object in water. To be sure, if you used a spring scale to weigh the object in each case, you would get a smaller reading when the object is underwater. But this doesn't mean that the earth is pulling less hard on the object. It's just that the spring scale is being assisted by the buoyant force in holding the object up. So the spring scale doesn't have to push upward as hard to keep the object up when it is underwater. Since the spring scale reading indicates how hard the spring scale is pushing upward upon whatever object is resting on it, the spring scale reading is smaller when the object is under water. The spring scale reading is not equal to the magnitude of the weight of the object. It is equal to the magnitude of the weight of the object, minus the magnitude of the buoyant force.

Consider a helium-filled balloon and a solid granite rock of the same size and shape. The reason that the heliumfilled balloon floats in air whereas the rock sinks in water is:

> Selected $\quad \times$ The buoyant force exerted on the balloon by the air is less than the buoyant force exerted on Answer: the rock by the water.

> Correct $\quad \checkmark$ The buoyant force exerted on the balloon by the air is greater than the weight of the balloonAnswer: plus-helium whereas the buoyant force exerted on the rock by the water is less than the weight of the rock.

Feedback: Interestingly enough, the buoyant force on the rock is greater than the buoyant force on the balloon (because the balloon is submerged in air whereas the rock is submerged in water which has a greater density than air, the weight of that amount of fluid that would be where the object is if the object wasn't there is greater in the case of the rock). It's not the buoyant force alone that determines whether the object sinks or rises, it's the vector sum of the buoyant force and the weight. While, of the two, the balloon has the smaller buoyant force on it, it has an even smaller weight so the net force on the balloon is upward. And, while of the two, the rock has the greater buoyant force on it, it has an even greater weight so the net force on the rock is downward.

## Question 9

0 of 10 points
Assume that you are in a bowling alley and you see a bowling ball (of the sort that has no finger holes) and a heliumfilled balloon that has the exact same size and shape as the bowling ball. On which object is the buoyant force greater?

Selected Answer: $\times$ The bowling ball.
Correct Answer: $\checkmark$ Neither, the magnitude of the buoyant force is not zero, but it is the same on both objects.
Feedback: Both objects are totally submerged in air so there is indeed a buoyant force on each. By Archimedes's principle, the buoyant force is equal in magnitude to the weight of that amount of air that would be where the object is if the object wasn't there. Since each object takes up the same amount of space in the air, the amount of air that would be where the object is if the object wasn't there is the same in both cases. Thus the buoyant force is the same.

If you hold each object at waist level and release it, the balloon accelerates toward the ceiling whereas the bowling ball accelerates toward the floor. The balloon doesn't rise because the buoyant force on it is greater, it rises because its weight is smaller than the buoyant force (so the net force on it is upward). Likewise the bowling ball doesn't fall because the buoyant force on it is smaller than that on the balloon, it falls because its weight is greater than the buoyant force (so the net force on it is downward).

## Question 10

Consider two identical basketballs. One is floating at rest in (on the surface of) fresh water and the other is floating at rest in (at the surface of) saltwater. Saltwater is more dense than fresh water. On which basketball is the buoyant force greater?

Selected Answer: $\times$ The one in fresh water.
Correct Answer: $\checkmark$ Neither.
Feedback: In each case, the buoyant force is equal in magnitude to the weight of the ball. The greater densisty of saltwater means that the ball in saltwater floats higher (less of it is submerged) than the ball in fresh water does, but the buoyant force on each ball is the same.

## Review Assessment: Lec 34 Quiz

Name: Lec 34 Quiz

## Status: Completed

Score: $\quad 30$ out of 100 points

## Instructions:

## Question 1

According to Bernoulli's principle, all other things being equal, for a non-viscous incompressible fluid undergoing streamline flow:

Selected Answer: $\times$ Fluid velocity in a pipe is greater where the diameter of the pipe is smaller.
Correct Answer: $\checkmark$ The pressure in a fluid is lower where the fluid is moving faster.
Feedback: The "all other things being equal" just refers to the elevation of the fluid. Consider two different positions in the same non-viscous incompressible fluid, a fluid which is undergoing streamline flow. Assume the fluid velocity at one point is different than the fluid velocity at the other. If the elevation of the fluid is the same at both points, then the gravitational potential energy per volume will be the same at both points, in which case the pressure is going to be lower where the fluid velocity is higher.

## Question 2

In the hydraulic system depicted below, the area of the face of the small piston on the left is $4.0 \mathrm{~cm}^{2}$. The area of the face of piston on the right is $625 \mathrm{~cm}^{2}$. The maximum force that the operator can apply to the piston on the left is his weight which is 730 newtons. With the aid of such a hydraulic system, the maximum load that the operator can lift is approximately how many times his weight?


Selected Answer: X 114000
Correct Answer: $\checkmark$ No other answer provided is correct.
Feedback:

$$
\begin{aligned}
& P_{L}=P_{A} \quad(L \text { for "LOAD", A for "APPLIED") } \\
& \begin{aligned}
\frac{F_{L}}{A_{L}} & =\frac{F_{A}}{A_{A}} \\
\frac{F_{L}}{F_{A}} & =\frac{A_{L}}{A_{A}} \\
& =\frac{625 \mathrm{~cm}^{2}}{4.0 \mathrm{~cm}^{2}} \\
& =156.25 \\
\frac{F_{L}}{F_{A}} & =160
\end{aligned} .
\end{aligned}
$$

What is the value of the gauge pressure at the bottom of a swimming pool which is 1.7 meters deep?

Selected Answer: $\times 190 \mathrm{~Pa}$
Correct Answer: $\checkmark$ No other answer provided is correct.
Feedback:

$$
\begin{aligned}
& \text { GAUGE PRESSURE } \\
& \text { GGTMOSPHERKC PRESURE } \\
& P_{G}=P-P_{0}^{\text {ATM }} \\
& \text { BUT } P=P_{0}+\rho g h \\
& \text { SO: } \\
& P_{G}= P_{0}+\rho g^{h}-P_{0} \\
& P_{G}= \rho g h \\
& P_{G}= 1.00 \times 10^{3} \frac{\mathrm{~kg}}{\mathrm{~m}^{3}}\left(9.80 \frac{\mathrm{~N}}{\mathrm{~kg}}\right) 1.7 \mathrm{~m} \\
& P_{G}= 16660 \frac{\mathrm{~N}}{\mathrm{~m}^{2}} \\
& P_{G}= 17 \mathrm{kPa}
\end{aligned}
$$

## Question 4

10 of 10 points
A vertical steel pipe, 22 meters in length, is closed at the bottom and filled up to the 21 -meter mark with water. A person seals off the top of the pipe with a fitting that allows her to pump air into the pipe. She pumps air into the pipe, increasing the pressure of the air in the pipe by 220000 pascals (2 dignificant figures). By how much does the pressure in the bottom of the pipe increase as a result of the pumping of air?

Selected Answer: $\checkmark 220000$ pascals (2 dignificant figures)
Correct Answer: $\checkmark 220000$ pascals (2 dignificant figures)
Feedback: Way to go. According to Pascal's principle, if the pressure in a fluid changes at one point in the fluid, it changes by the same amount everywhere else in the fluid.

At a submarine escape training facility, a $150-\mathrm{ft}$ deep "swimming pool" consists of a tower supporting a $10-\mathrm{ft}$ diameter vertical steel cylinder, 160 feet tall, sealed at the bottom and filled to the 150 -foot mark with water. Compare the pressure at the bottom of this training tank with the pressure at the bottom of a 1 -inch vertical pipe, 160 -feet tall, sealed at the bottom and filled with water to the 150 -foot mark.

Selected
Answer:
Correct Answer: $\checkmark$ The pressure at the bottom of the 1 -inch pipe is the same as the pressure at the bottom of the tank.

Feedback: Nice job. The diameter of the container does not matter. In determining the pressure in water on the earth, only the depth matters.

How deep would a freshwater lake have to be so that the pressure at the bottom of the lake is 2.00 atmospheres?
Selected Answer: $\downarrow 10.3$ meters

Correct Answer: $\checkmark 10.3$ meters
Feedback: Nice work!
Note that $1 \mathrm{~atm}=101.3 \mathrm{kPa}$. Also, the pressure at the top of a lake is already 1 atm . Watch out! An atmosphere is not an SI unit. If you need to use a pressure value given in units of atmospheres in an equation that has quantities with SI units, you need to convert atmospheres to pascals. A pascal is an SI unit; it is just a $\mathrm{N} / \mathrm{m}^{2}$.


## Question 7

0 of 10 points
The simple closed-loop piping system depicted below is completely full of water flowing in the direction indicated by the arrows. At which position (A or $B$ ) in the pipe is the flow rate greater?


Selected Answer: X A
Correct Answer: $\checkmark$ Neither
Feedback: The flow rate at $B$ is the same as the flow rate at $A$.
We are being asked how much water per second flows past position A as compared to how much water per second flows past position B. Consider the region between $A$ and $B$. Because the pipe, including that segment, is completely full of water, the amount of water in that segment of the pipe is always the same. That means that as any amount of water flows, at $A$, into the pipe segment, an equal amount must flow out of that segment of the pipe, at B; otherwise the amount of water in that region (the region between $A$ and $B$ ) would be changing. That means that the flow rate into the region, at $A$, must be the same as the flow rate out of the region, at $B$. Note that this is not a Bernoulli Principle question. The principle under consideration here (under steady state conditions, the flow rate into a pipe segment has to be the same as the flow rate out of the same pipe segment) comes under the heading of the Continuity Equation.

The simple closed-loop piping system depicted below is completely full of water. At which position (A or B) is the fluid velocity greater?


Selected Answer: $\times \mathrm{A}$
Correct Answer: $\checkmark \mathrm{B}$
Feedback: In accord with the continuity equation, the flow rate (amount per time which could for example be measured in gallons per minute) at $A$ is the same as the flow rate at $B$. But the pipe is skinnier at $B$ than it is at $A$. In order for the same number of gallons-per-minute to flow through the skinny pipe at $B$ as flow through the fat pipe at $A$, the water must be flowing faster at $B$.

## Question 9

0 of 10 points
The simple closed-loop piping system depicted below is completely full of water flowing in the direction indicated by the arrows. At which position ( C or D ) in the pipe is the flow rate greater?


Selected Answer: $\times$ C
Correct Answer: $\checkmark$ Neither
Feedback: The flow rate is the same at $C$ as it is at $D$. A lot of people think that the effect of a pump in a closed system is to make the flow rate greater at the outlet of the pump than it is at the inlet. But for every gallon that flows out of the pump at D a gallon has to flow into the pump at C . So the flow rate at C is just as great as the flow rate at $D$. If the pump is used to increase the flow rate of the water, it increases it everywhere at once. In the case of a single-path closed-loop system, at any given instant in time, there is only one flow rate in the entire system--the flow rate is always the same at all points in the system.

## Question 10

0 of 10 points
The simple closed-loop piping system depicted below is completely full of water flowing in the direction indicated by the arrows. At which position (C or D ) in the pipe is the velocity of the water greater? (Note that the pipe diameter has one and the same value at each of the two locations.)


Selected Answer: $\times$ C
Correct Answer: $\checkmark$ Neither

Feedback: The velocity of the water is the same at $C$ as it is at $D$. If the water was flowing at higher speed at $D$ than at C , then, because the cross-sectional area of the pipe at D is the same as it is at C , the flow rate would be greater at $D$. But we know from the continuity equation that the flow rate is the same at $D$ as it is at $C$. (You cannot have more water flowing out of the pump than is flowing into it because the pump does not manufacture water, it just pushes it around.) Therefore, the velocity of the water at $D$ must be the same as it is at $C$.

## Review Assessment: Lec 35 Quiz

| Name: | Lec 35 Quiz |
| :--- | :--- |
| Status : | Completed |
| Score: |  |
|  | 19 out of 100 points |

## Instructions:

## Question 1

0 of 19 points
Which of the following best characterizes heat?

Selected $\times$ A characteristic of a material--a measure of the average kinetic energy of a molecule of that Answer: material.

Correct $\quad \checkmark$ Energy that is transferred or in the process of being transferred from one sample of matter to Answer: another because of a temperature difference between the two samples.

Feedback: Heat is energy in transit. Upon flowing into a sample of matter it becomes part of the internal energy of the sample of matter.

Is it possible for there to be a net flow of heat into an otherwise isolated system without there being an increase in the internal energy of that system?

Selected Answer: $\times$ Yes
Correct Answer: $\checkmark$ No
Feedback: That's what heat does when it flows into a closed system, it increases the internal energy of that system.

## Question 3

0 of 19 points
What is internal energy?

Selected $\times$ A characteristic of a material--a measure of the average kinetic energy of a molecule of that Answer: material.

Correct $\quad \checkmark$ The sum total of all (except that associated with the bulk motion/position of the sample as a Answer: whole) the energy of all the molecules making up a sample of matter (e.g. an object).

Feedback: Energy transferred or being transferred is heat, not internal energy.
Some of the internal energy can be in the form of the kinetic energy of molecules, but, some of it can also be in the form of potential energy, in particular the electrostatic potential energy (the energy associated with the repulsion of like charges that make up matter, as well as the attraction of unlike charges that make up matter).

Note that the energy of the sample of matter taken as a whole is not internal energy. For instance, if the sample is a rock of mass M and the rock is moving through space at speed v , the kinetic energy $1 / 2 \mathrm{Mv}^{2}$ of the rock as a whole is not part of the internal energy of the rock. The potential energy of the sample of matter taken as a whole is also not internal energy. In the case of the rock just mentioned for instance, if it is a height h above some specified reference level, the potential energy Mgh of the rock taken as a whole is not part of the internal energy of the rock.

The rock is completely submerged in the water. The container is thermally isolated (meaning no heat can flow into or out of the interior of the container) and has negligible heat capacity. The entire process takes place at atmospheric pressure. Which of the following is/are necessarily true? (Indicate all the correct answers.)
Selected
Answers:
Correct
Answers: After a long time, the rock and water are at 100 degrees Celsius.

and 95 degrees but the value of that temperature cannot be determined without further information.
equal to the amount of heat that flows into the the water.

Feedback: Heat flows from hot to cold so heat will flow from the rock into the water. This will lower the temperature of the rock and increase the temperature of the water. The heat flow will occur until the rock and the water are at one and the same temperature somewhere in between the initial temperatures. But without any information on the mass of the rock, the mass of the water, or the heat capacity of the rock there is no way to tell exactly what that temperature will be. With a small rock and a lot of water, the final temperature could be very close to (but above) the initial water temperature. At the other extreme, where the rock just barely fits in the container and the water just covers the rock, the final temperature could be very close to (but below) the initial temperature of the rock. There is just no way of knowing the final temperature without more information.

Is it possible for there to be a net flow of heat into an otherwise isolated system without there being an increase in the temperature of that system?

Selected Answer: $\checkmark$ Yes
Correct Answer: $\checkmark$ Yes
Feedback: Nice work!
The internal energy of a closed system will necessarily increase when heat flows into that system. The temperature, however, is dependent on just the internal kinetic energy of the system. The internal energy consists of both kinetic energy and potential energy. It is possible for all the heat that flows into a system to go into increasing the internal potential energy of the system while leaving the internal kinetic energy unchanged. This occurs for instance, when heat is added to a solid that is at the melting temperature. Adding heat converts the solid to liquid at the same temperature (until you run out of solid).

## Review Assessment: Lec 36 Quiz

| Name: | Lec 36 Quiz |
| :--- | :--- |
| Status : | Completed |
| Score: | 15 out of 100 points |

## Instructions:

## Question 1

## 0 of 30 points

A solid chunk of a substance (sample \#1) is placed in a container of the same substance (sample \#2) in liquid form. Both samples of the material are initially at one and the same pressure. The container is sealed such that no heat can flow into or out of the container, but, such that the pressure inside is maintained at the initial pressure of the samples. The heat capacity of the container is negligible. Which of the following outcomes are not ruled out by the limited information given? (Assume that enough time passes for the contents of the container to come to equilibrium. Select every correct answer.)

Selected Answers: $\checkmark$ The temperature of sample \#1 could increase.
Correct Answers: $\checkmark$ The temperature of sample \#1 could increase.
$\checkmark$ The temperature of sample \#1 could stay the same.
$\checkmark$ The temperature of sample \#2 could decrease.

- The temperature of sample \#2 could stay the same.


## Question 2

0 of 35 points
A solid chunk of a substance is placed in a container of the same substance in liquid form. Both samples of the material are initially at one and the same pressure. The container is sealed such that no heat can flow into or out of the container, but, such that the pressure inside is maintained at the initial pressure of the samples. The heat capacity of the container is negligible. Which of the following outcomes are not ruled out by the limited information given? (Assume that enough time passes for the contents of the container to come to equilibrium. Select every correct answer.)

Selected $\quad \times$ There could be a positive net flow of heat from the solid to the liquid with neither of the original Answers: samples experiencing a phase change. The temperature of the liquid would increase while the temperature of the solid would decrease until both the solid and the liquid were at one and the same temperature, with neither sample having undergone a phase change.

Correct $\quad \checkmark$ There could be a positive net flow of heat from the liquid to the solid with neither of the original Answers: samples experiencing a phase change. The temperature of the solid would increase while the temperature of the liquid would decrease until both the solid and the liquid were at one and the same temperature.
$\checkmark$ The liquid could remain a liquid and the solid could remain a solid with neither experiencing a change in temperature.
$\checkmark$ All the liquid could turn to solid.
$\checkmark$ All the solid could turn to liquid.
$\checkmark$ Some of the liquid could turn to a solid.
$\checkmark$ Some of the solid could turn to a liquid.

At a manufacturing plant, molten iron is poured into a cast in the making of an iron frying pan. While the liquid iron is turning into solid iron, what happens to the temperature of the frying pan?

Selected Answer: $\times$ It increases.
Correct Answer: $\checkmark$ It stays the same.

## Question 4

15 of 15 points
Is it possible for there to be a net positive flow of heat into a substance without the temperature of that substance increasing?


Selected Answer: $\checkmark$ Yes
Correct Answer: $\checkmark$ Yes

## 园且 Review Assessment: Lec 37 Quiz

| Name: | Lec 37 Quiz |
| :--- | :--- |
| Status: | Completed |
| Score: | 100 out of 100 points |

Instructions:

## Question 1

100 of 100 points
The First Law of Thermodynamics is a statement of the principle of conservation of what?

Selected Answer: $\checkmark$ Energy
Correct Answer: $\checkmark$ Energy
Feedback: Nice work!


[^0]:    $(7)$

