

## Practice Final Exam Key

- B** 1. A rock is thrown vertically upward from ground level at time  $t = 0$ . At  $t = 1.9$  s it passes the top of a tall tower, and 1.0 s later it reaches its maximum height. What is the height of the tower?
- A. 21.8 m
  - B. 36.3 m
  - C. 39.9 m
  - D. 49.9 m
  - E. 62.1 m

At the top, velocity of the rock is zero.  $v = v_0 - gt = v_0 - 9.8 \times (1.9 + 1.0) = v_0 - 28.42 = 0$  .  
 $\rightarrow v_0 = 28.42$  .

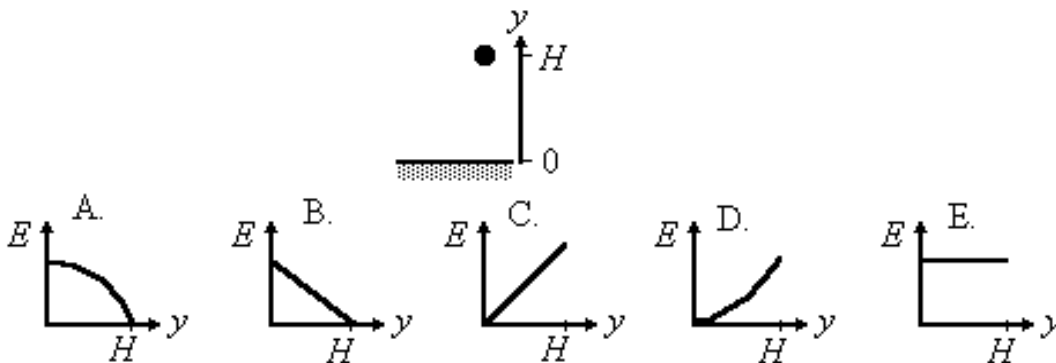
At  $t = 1.9$  s, the height of the rock is

$$Y = v_0 t - \frac{1}{2} g t^2 = 28.42 \times 1.9 - \frac{1}{2} \times 9.8 \times 1.9^2 = 52.375 - 17.689 = 36.309$$

The height of the tower is 36.3m.

$\rightarrow$  B

- E** 2. A ball is held at a height  $H$  above a floor. It is then released and falls to the floor. If air resistance can be ignored which of the five graphs below correctly gives the total mechanical energy  $E$  of the earth-ball system as a function of the altitude  $y$  of the ball?



Since the gravitational force is conservative force, the energy is conserved regardless of the height.

$\rightarrow$  E

- C 3. Blocks A and B are moving toward each other on a frictionless horizontal surface. Block A has a mass of 2.0 kg and a velocity of +50 m/s  $\hat{i}$ , while B has a mass of 4.0 kg and a velocity of -25 m/s  $\hat{i}$ . They collide and stick together. The kinetic energy lost during the collision is:

- A. 0 J
- B. 1250 J
- C. 3750 J**
- D. 5000 J
- E. 5600 J

From the momentum conservation law,  $(m_A + m_B)v_f = m_A v_A + m_B v_B \rightarrow$

$$v_f = \frac{m_A v_A + m_B v_B}{m_A + m_B} = \frac{2 \times 50 \hat{i} + 4(-25) \hat{i}}{2 + 4} = 0$$

$$\begin{aligned} \Delta K &= K_f - K_i = \frac{1}{2}(m_A + m_B)v_f^2 - \left( \frac{1}{2}m_A v_A^2 + \frac{1}{2}m_B v_B^2 \right) \\ &= \frac{1}{2}(2 + 4) \cdot 0^2 - \left( \frac{1}{2} \cdot 2 \cdot 50^2 + \frac{1}{2} \cdot 4 \cdot (-25)^2 \right) \\ &= - \left( 50^2 + 2 \cdot (-25)^2 \right) = - (2500 + 1250) = -3750 J \end{aligned}$$

$\rightarrow$ C

- D 4. Given the following three vectors:

$$\begin{aligned} \vec{a} &= -9.3\text{m} \hat{i} + 2.7\text{m} \hat{j} + 5.2\text{m} \hat{k} \\ \vec{b} &= -2.0\text{m} \hat{i} - 4.0\text{m} \hat{j} + 2.0\text{m} \hat{k} \\ \vec{c} &= 2.0\text{m} \hat{i} + 3.0\text{m} \hat{j} + 1.0\text{m} \hat{k} \end{aligned}$$

What is the result of  $\vec{a} \cdot (\vec{b} + \vec{c})$  ?

- A. 4.3 m<sup>2</sup>
- B. 7.3 m<sup>2</sup>
- C. 10.5 m<sup>2</sup>
- D. 12.9 m<sup>2</sup>**

$$\begin{aligned} \vec{b} + \vec{c} &= (-2.0\hat{i} - 4.0\hat{j} + 2.0\vec{k}) + (2.0\hat{i} + 3.0\hat{j} + 1.0\vec{k}) \\ &= (-2.0 + 2.0)\hat{i} + (-4.0 + 3.0)\hat{j} + (2.0 + 1.0)\vec{k} \\ &= 0\hat{i} - 1.0\hat{j} + 3.0\vec{k} \end{aligned}$$

$$\begin{aligned}\vec{a} \cdot (\vec{b} + \vec{c}) &= (-9.3\hat{i} + 2.7\hat{j} + 5.2\vec{k}) \cdot (0\hat{i} - 1.0\hat{j} + 3.0\vec{k}) \\ &= -9.3 \cdot 0(\hat{i} \cdot \hat{i}) + 2.7 \cdot (-1.0)(\hat{j} \cdot \hat{j}) + 5.2 \cdot 3.0(\vec{k} \cdot \vec{k}) \\ &= 0 - 2.7 + 15.6 = 12.9\end{aligned}$$

Each of vectors has a unit of m, so the product of two vectors has unit of  $m^2$ .

→D

- B** 5. A ball is thrown horizontally from the top of a 20 m high hill. It strikes the ground at an angle of  $45^\circ$  as shown in the figure. With what speed was the ball thrown? Neglect air resistance.



- A. 13.6 m/s
- B. 19.8 m/s**
- C. 27.7 m/s
- D. 31.4 m/s
- E. 35.1 m/s

The ball takes a certain time to reach the ground and is

$$Y = Y_0 + v_{0y}t - \frac{1}{2}gt^2 \rightarrow 0 = 20 + 0t - \frac{1}{2}9.8t^2 \rightarrow 20 = 4.9t^2 \rightarrow t = \sqrt{\frac{20}{4.9}} = 2.02 \text{ sec}$$

The vertical component of the velocity at the ground is

$$v_y = v_0 - gt = 0 - 9.8 \times 2.02 = -19.796 \text{ m/s}$$

Since the ball hits the ground at the angle of  $-45^\circ$ ,  $\tan \theta = \frac{v_x}{v_y} \rightarrow \tan(-45^\circ) = -1 = \frac{v_x}{v_y} \rightarrow$

$$v_x = -v_y = 19.796 \text{ m/s}$$

→B

- D** 6. A car is moving due South. What is the direction of the torque on the wheels while it slows down?

- A. North
- B. South
- C. East
- D. West**

The direction of the angular velocity of the wheel is EAST.

When the wheel is slowing down, the direction of the angular acceleration is opposite to the direction of the angular velocity. → WEST.

The direction of torque and the direction of angular acceleration is always the same,  $\vec{\tau} = I\vec{\alpha}$  (since torque is always positive value) → WEST.

→D

D 7. A planet has a mass of 0.0558 times the mass of Earth and a radius of 0.381 times the radius of Earth. The acceleration of a body falling near the surface of the planet is about:

- A. 0.21 m/s<sup>2</sup>
- B. 1.4 m/s<sup>2</sup>
- C. 2.8 m/s<sup>2</sup>
- D. 3.8 m/s<sup>2</sup>**
- E. 7.5 m/s<sup>2</sup>

Gravitational force acts on a body is given by

$$F \circ m_{\text{body}} g_{\text{planet}} = G \frac{M_{\text{planet}} m_{\text{body}}}{r_{\text{planet}}^2} = G \frac{0.0558 M_{\text{earth}} m_{\text{body}}}{(0.381 r_{\text{earth}})^2} = 0.3844 G \frac{M_{\text{earth}} m_{\text{body}}}{r_{\text{earth}}^2} \circ m_{\text{body}} (0.3844 g_{\text{earth}})$$

$$g_{\text{planet}} = 0.3844 g_{\text{earth}} = 0.3844 \times 9.8 = 3.76 \text{ m/s}^2$$

→D

B 8. A constant force of 8.0 N is exerted for a duration of 4.0 s on an object of mass 16 kg initially at rest. The change in speed of this object will be:

- A. 0.5 m/s
- B. 2.0 m/s**
- C. 4.0 m/s
- D. 8.0 m/s
- E. 32 m/s

Use the impulse-momentum theorem.

$$J \equiv \int F dt = F \Delta t = \Delta p = p_f - p_i$$

$$F \Delta t = 8 \cdot 4$$

$$= p_f - p_i = mv_f - m \cdot 0 = mv_f \rightarrow mv_f = 32 \rightarrow v_f = \frac{32}{m} = \frac{32}{16} = 2.0 \text{ m/s}$$

→B

D 9. A stationary source S generates circular outgoing waves on a lake. The wave speed is 5.0 m/s and the crest-to-crest distance is 2.0 m. A person in a motor boat heads directly toward S at a speed of 3.0 m/s. To this person, the frequency of the waves is:

- A. 1.0 Hz
- B. 1.5 Hz
- C. 2.0 Hz
- D. 4.0 Hz**
- E. 8.0 Hz

The frequency of the wave from the source is given by follow.

$$f = \frac{v}{\lambda} = \frac{5}{2} = 2.5 \text{ Hz}$$

The frequency observed on the boat is

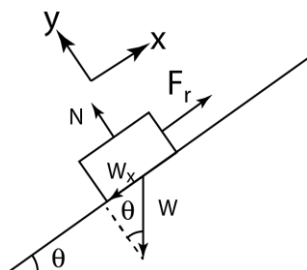
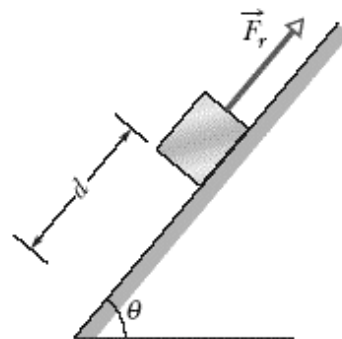
$$f' = f \frac{v + v_{\text{boat}}}{v} = 2.5 \times \frac{5 + 3}{5} = 4 \text{ Hz}$$

(The boat (detector) is towards the source and sees the crest more often than the static observer.)

→D

- E 10.** A 32-N force, parallel to the incline, is required to push a certain crate at constant velocity up a frictionless incline that is  $\theta = 30^\circ$  above the horizontal (see figure). What is the mass of the crate?

- A. 2.5 kg
- B. 3.3 kg
- C. 3.8 kg
- D. 5.7 kg
- E. 6.5 kg**



For the crate to move at a constant speed along the incline, the total force in the x direction must be zero.

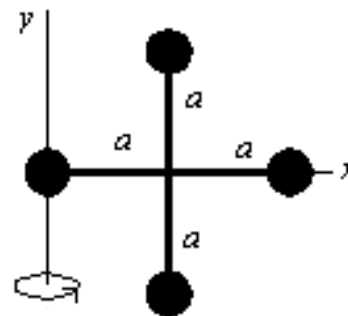
$$F_{\text{total}}^x = -W_x + F_r = -W \sin \theta + F_r = -mg \sin 30^\circ + F_r = -m \times 9.8 \times 0.5 + 32 = 0$$

$$\rightarrow m = \frac{32}{9.8 \times 0.5} = 6.53 \text{ kg}$$

→E

- D 11.** Four identical particles, each with mass  $m = 2.0 \text{ kg}$ , are arranged in the  $x, y$  plane as shown. They are connected by 4 identical sticks of length  $a = 1.0 \text{ m}$  but negligible mass to form a rigid body. What is the rotational inertia of this body about the  $y$ -axis?

- A.  $4.0 \text{ kg m}^2$
- B.  $4.8 \text{ kg m}^2$
- C.  $9.6 \text{ kg m}^2$
- D.  $12 \text{ kg m}^2$**
- E. None of these



$$I = \sum_i m r_i^2 = m 0^2 + m a^2 + m a^2 + m (2a)^2 = 6ma^2 = 6 \times 2 \times 1 = 12 \text{ kgm}^2$$

→ D

**D** 12. A block of mass 0.5 kg attached to an ideal spring with a spring constant of 80 N/m oscillates on a horizontal frictionless surface. At a time, where the spring is 4.0 cm longer than its equilibrium length, the speed of the block is 0.50 m/s. What is the greatest speed of the block?

- A. 0.23 m/s
- B. 0.32 m/s
- C. 0.55 m/s
- D. 0.71 m/s**
- E. 0.93 m/s

The total energy is conserved in the system, and the speed of the block becomes maximum when the potential energy becomes zero (at the equilibrium position).

$$E = K_{4cm} + U_{4cm} = K_{\max} \rightarrow K_{4cm} + U_{4cm}$$

$$K_{\max} = K_{4cm} + U_{4cm} = \frac{1}{2} m v_{4cm}^2 + \frac{1}{2} k x^2 = \frac{1}{2} \times 0.5 \times 0.5^2 + \frac{1}{2} \times 80 \times 0.04^2 = 0.1265$$

$$\rightarrow K_{\max} = \frac{1}{2} m v_{\max}^2 = \frac{1}{2} \times 0.5 \times v_{\max}^2 = 0.1265$$

$$\rightarrow v_{\max}^2 = \frac{2 \times 0.1265}{0.5} = 0.506$$

$$\rightarrow v_{\max} = 0.711 \text{ m/s}$$

→ D

**B** 13. Consider a cylinder of radius 0.10 m and length 0.20 m. Its rotational inertia, round the cylinder axis is 0.020 kg m<sup>2</sup>. A string is wound around the cylinder and pulled with a force of 1.0 N perpendicular to the cylinder's axis. What is the angular acceleration of the cylinder ?

- A. 2.5 rad/s<sup>2</sup>
- B. 5.0 rad/s<sup>2</sup>**
- C. 10 rad/s<sup>2</sup>
- D. 15 rad/s<sup>2</sup>
- E. 20 rad/s<sup>2</sup>

The torque on the cylinder can be expressed in two ways as follow.

$$\tau = I a = r \times F$$

$$\rightarrow a = \frac{r \times F}{I}$$

Magnitude of the acceleration is  $|a| = \frac{|r \times F|}{I} = \frac{rF \sin q}{I} = \frac{rF \sin 90^\circ}{I} = \frac{0.1 \times 1.0 \times 1}{0.02} = 5.0 \text{ rad/s}^2$

→ B

**D** 14. A 3-kg block, attached to a spring, executes simple harmonic motion according to  $x = 2\cos(50t)$  where  $x$  is in meters and  $t$  is in seconds. The spring constant of the spring is:

- A. 100 N/m
- B. 1000 N/m
- C. 4500 N/m
- D. 7500 N/m**
- E. 9200 N/m

Compare to the general formula of a simple harmonic oscillator,

$$x = A \cos(\omega t) = 2 \cos(50t)$$

Angular velocity of the oscillator is  $\omega = 50 \text{ rad/sec}$

Angular frequency of a harmonic oscillator is given by  $\omega = \sqrt{\frac{k}{m}}$

$$\rightarrow \omega^2 = \frac{k}{m} \rightarrow k = m\omega^2 = 3 \times 50^2 = 7500 \text{ N/m}$$

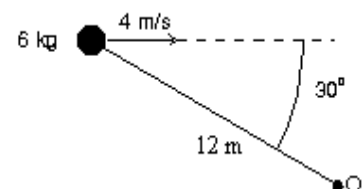
→ D

**A** 15. Two stationary tuning forks (350 Hz and 352 Hz) are struck simultaneously. The resulting sound is observed to:

- A. Beat with a frequency of 2 beats/s.**
- B. Beat with a frequency of 351 beats/s.
- C. Be loud but not beat.
- D. Be Doppler shifted by 2 Hz.
- E. Have a frequency of 702 Hz.

The beat frequency is the frequency difference of two waves,  $f_b = f_2 - f_1 = 352 - 350 = 2 \text{ Hz}$

**B** 16. A 6.0-kg particle moves to the right at 4.0 m/s as shown. In reference to point O on the right, what is the magnitude of the particle's angular momentum?



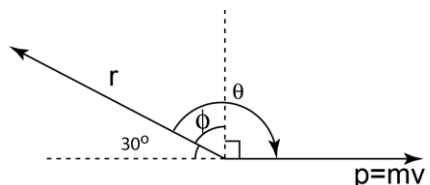
- A. 24 kg m<sup>2</sup>/s
- B. 144 kg m<sup>2</sup>/s**
- C. 249 kg m<sup>2</sup>/s
- D. 288 kg m<sup>2</sup>/s
- E. 0

$$\vec{l} = \vec{r} \times \vec{p} \rightarrow |\vec{l}| = |\vec{r} \times m\vec{v}| = rmv \sin \theta = rmv \sin 30^\circ = 12 \times 6 \times 4 \times 0.5 = 144 \text{ kgm}^2 / \text{s}$$

(Only vertical component of  $r$  in the figure contribute to the angular momentum.)

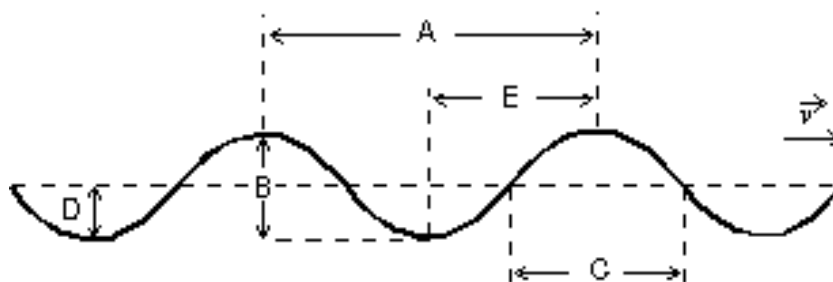
→B

(or from the figure below)



$$|\vec{l}| = |\vec{r} \times m\vec{v}| = rmv \sin \theta = rmv \sin \left( \frac{\pi}{2} + \phi \right) \\ = rmv \cos(\phi) = rmv \cos 60^\circ = 12 \cdot 6 \cdot 4 \cdot 0.5 = 144 \text{ kgm}^2 / \text{s}$$

The following two questions refer to this figure for a sinusoidal wave travelling to the right:



D 17. Which letter in the figure correctly labels the amplitude of the wave?

A 18. Which letter in the figure correctly labels the wavelength of the wave?

D 19. The tension in a string with a linear density of  $0.0010 \text{ kg/m}$  is  $0.40 \text{ N}$ . A  $100 \text{ Hz}$  sinusoidal wave on this string has a wavelength of:

- A.  $0.05 \text{ cm}$
- B.  $2.0 \text{ cm}$
- C.  $5.0 \text{ cm}$
- D.  $20 \text{ cm}$**
- E.  $100 \text{ cm}$



Angular frequency of string and tension and density are related as

$$v = \sqrt{\frac{t}{m}} = \sqrt{\frac{0.4}{0.001}} = 20 \text{ m/s}$$

$$l = \frac{v}{f} = \frac{20}{100} = 0.2 \text{ m} = 20 \text{ cm}$$

→ D

A 20. When a man on a frictionless rotating stool extends his arms horizontally, his rotational kinetic energy:

**A. Must decrease.**

B. Must increase.

C. Must remain the same.

D. May increase or decrease depending on his initial angular velocity

When he extends his arm, the inertia increases, but angular momentum stays constant.

$I_{ini} \omega_{ini} = I_{extend} \omega_{extend}$  So the angular velocity decreases. ( $\omega_{extend} = \frac{I_{ini}}{I_{extend}} \omega_{ini} < \omega_{ini}$ , since

$$I_{ini} < I_{extend})$$

Kinetic energy

$$K_{ini} = \frac{1}{2} I_{ini} \omega_{ini}^2 = \frac{1}{2} (I_{ini} \omega_{ini}) \omega_{ini}$$

$$K_{extend} = \frac{1}{2} I_{extend} \omega_{extend}^2 = \frac{1}{2} (I_{extend} \omega_{extend}) \omega_{extend} = \frac{1}{2} (I_{ini} \omega_{ini}) \omega_{extend}$$

(Here  $I_{ini} \omega_{ini} = I_{extend} \omega_{extend}$  was used.)

Since  $\omega_{ini} > \omega_{extend}$ , kinetic energy must decrease when he extends his arm.

→ A

B 21. The center of mass of a system of particles has a constant velocity if:

A. The forces exerted by the particles on each other sum to zero.

**B. The external forces acting on particles of the system sum to zero.**

C. The velocity of the center is initially zero.

D. The particles are distributed symmetrically around the center of mass.

E. The center of mass is at the geometric center of the system.

(No external force, no change in momentum. Hence, no change in the velocity.)

- E 22.** A block attached to a spring oscillates in simple harmonic motion along the  $x$  axis. The limits of its motion are  $x = 10$  cm and  $x = 50$  cm and it goes from one of these extremes to the other in a time of 0.25 s. What are its amplitude and frequency?
- A. 40 cm, 2 Hz
  - B. 20 cm, 4 Hz
  - C. 40 cm, 2 Hz
  - D. 25 cm, 4 Hz
  - E. 20 cm, 2 Hz**

Since the block moves between  $x = 10$  to  $x = 50$  cm, the middle point  $x_m = (10 + 50)/2 = 30$  is the equilibrium point. So the amplitude  $A = 50 - 30 = 20$  cm.

The block takes 0.25 s to move from one extreme to the other. Since this is a half of the cycle, the period  $T = 0.25 \times 2 = 0.5$  sec.

Frequency is  $f = 1/T = 1/0.5 = 2$  Hz.

→E

- E 23.** A playground merry-go-round has a radius  $R$  and a rotational inertia  $I$ . When the merry-go-round is at rest, a child with mass  $m$  runs with speed  $v$  along a line tangent to the rim and jumps on. The angular velocity of the merry-go-round is then:
- A.  $mv/I$
  - B.  $v/R$
  - C.  $mRv/I$
  - D.  $2mRv/I$
  - E.  $mRv/(mR^2 + I)$**

Since the angular momentum before and after the child jumps on the merry-go-around is conserved.  $I\omega_0 + R \times p = (I + mR^2)\omega_{final}$

The merry-go-around was at rest before,  $\omega_0 = 0$ .

The magnitude of the angular velocity after is

$$|\omega_{final}| = \left| \frac{R \times p}{I + mR^2} \right| = \frac{Rmv \sin 90^\circ}{I + mr^2} = \frac{Rmv}{I + mR^2}$$

→E

- C 24.** Let  $F_1$  be the magnitude of the gravitational force exerted on the Sun by Earth and  $F_2$  be the magnitude of the force exerted on Earth by the Sun. Then:
- A.  $F_1$  is much greater than  $F_2$ .
  - B.  $F_1$  is slightly greater than  $F_2$ .
  - C.  $F_1$  is equal to  $F_2$ .**
  - D.  $F_1$  is slightly less than  $F_2$ .
  - E.  $F_1$  is much less than  $F_2$ .

(They are Newton's third law pair. Magnitude is the same, the direction is opposite.)

- E** 25. A traveling wave on a string is described by  $y = 7.9 \sin[2\pi(t/0.87 + x/90)]$  where  $x$  and  $y$  are in meters and  $t$  is in seconds. Determine the wave velocity, including direction (+ if the wave is moving in the + $x$  direction, - if it is moving in the - $x$  direction).

- A. -0.0097 m/s
- B. 16 m/s
- C. -16 m/s
- D. 100 m/s
- E. -100 m/s**

Velocity is given by  $v = \frac{w}{k} = f /$

General formula of wave is given by

$$y = A \sin(kx + wt) = A \sin\left(\frac{2\pi}{\lambda}x + 2\pi ft\right)$$

$$\rightarrow v = f / = \frac{1}{0.87} 90 = 103.4 \text{ m/s}$$

The wave is propagating to - $x$  direction.

$\rightarrow v < 0$

$\rightarrow$  E

- A** 26. A flywheel is initially rotating at 20 rad/s and has a constant angular acceleration. After 9.0 s it has rotated through 450 rad. What is its angular acceleration?

- A. 6.7 rad/s<sup>2</sup>**
- B. 7.5 rad/s<sup>2</sup>
- C. 8.6 rad/s<sup>2</sup>
- D. 9.9 rad/s<sup>2</sup>
- E. 11 rad/s<sup>2</sup>

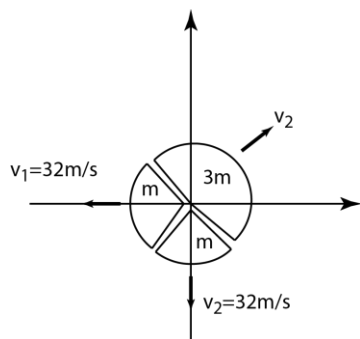
Use constant angular acceleration formula.

$$q = w_0 t + \frac{1}{2} a t^2 \rightarrow a = 2 \frac{q - w_0 t}{t^2} = 2 \frac{450 - 20 \times 9}{9^2} = 6.66 \text{ rad/s}^2$$

$\rightarrow$  A

- C** 27. An object at rest at the origin of an  $xy$  coordinate system explodes into three pieces. Just after the explosion, one piece, of mass  $m$ , moves with velocity  $(-32 \text{ m/s})\hat{i}$  and a second piece, also of mass  $m$ , moves with velocity  $(-32 \text{ m/s})\hat{j}$ . The third piece has mass  $3m$ . Just after the explosion, what is the magnitude of the velocity of the third piece?

- A. 5.70 m/s
- B. 10.6 m/s
- C. 15.0 m/s**
- D. 21.2 m/s
- E. 25.0 m/s



Take three objects as a system, the force split the object is an internal force, and momentum before and after the explosion is conserved.

$$X: 0 = mv_1 + 3mv_{3x}$$

$$Y: 0 = mv_2 + 3mv_{3y}$$

$$\rightarrow v_{3x} = -\frac{1}{3}v_1 = -\frac{1}{3}(-32) = \frac{32}{3}$$

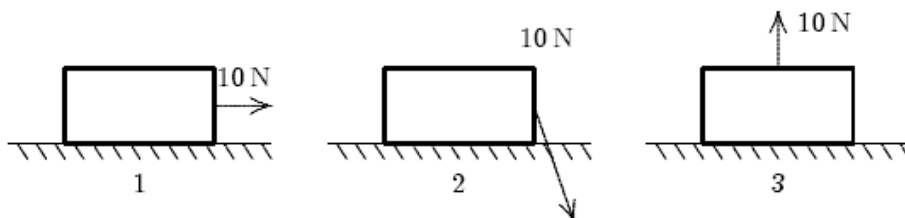
$$\rightarrow v_{3y} = -\frac{1}{3}v_2 = -\frac{1}{3}(-32) = \frac{32}{3}$$

Magnitude of the velocity of the object 3 is

$$v_3 = \sqrt{v_{3x}^2 + v_{3y}^2} = \sqrt{\left(\frac{32}{3}\right)^2 + \left(\frac{32}{3}\right)^2} = \frac{32}{3}\sqrt{2} = 15.06 \text{ m/s}$$

→C

E 28. A crate moves 10 m to the right on a horizontal surface as a woman pulls on it with a 10-N force. Rank the situations shown below according to the work done by her force, **greatest to least**.



A. 1, 3, 2

B. 2, 3, 1

C. 2, 1, 3

D. 3, 2, 1

**E. 1, 2, 3**

Work by a constant force is given by  $W = F \times d = Fd \cos q$

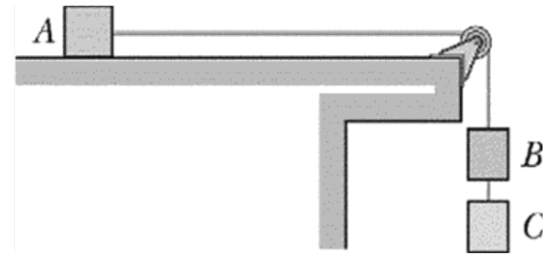
$q = 0$  for 1 →  $W = F \times d = Fd \cos q = Fd \cos 0 = Fd$

$q = \frac{\rho}{2}$  for 3 →  $W = F \times d = Fd \cos q = Fd \cos \frac{\rho}{2} = 0$

$0 < q < \frac{\rho}{2}$  for 2 →  $W = F \times d = Fd \cos q < Fd$

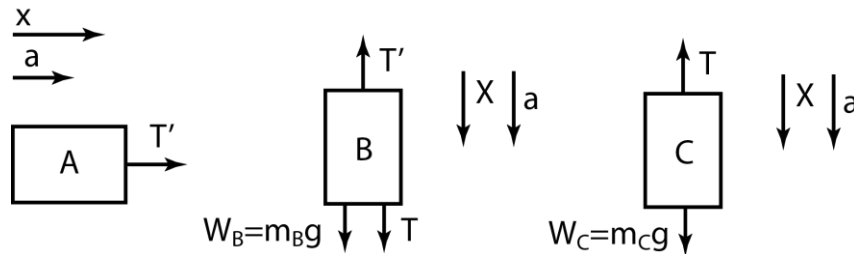
→E

- B 29. In the figure shown three boxes are connected by cords, one of which wraps over a pulley having negligible friction on its axle and negligible mass. The masses are  $m_A = 32$  kg,  $m_B = 44$  kg, and  $m_C = 14$  kg. After the assembly is released from rest, what is the tension in the cord connecting B and C?



- A. 31.6 N  
**B. 48.8 N**  
 C. 72.8 N  
 D. 137 N  
 E. 431 N

Free body diagram of each objects are:



Newton's 2<sup>nd</sup> law:

$$F_A = T' = m_A a$$

$$F_B = T + m_B g - T' = m_B a$$

$$F_C = m_C g - T = m_C a$$

Find acceleration  $a$ , and then substitute the acceleration,  $a$  into the third equation to get  $T$ .  
 Adding three equation together,

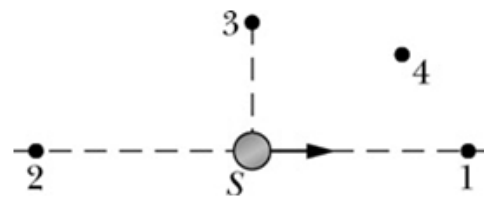
$$m_B g + m_C g = (m_A + m_B + m_C) a \rightarrow a = \frac{m_B + m_C}{m_A + m_B + m_C} g$$

From the third equation,

$$\begin{aligned} T &= m_C g - m_C a = m_C (g - a) = m_C \left( 1 - \frac{m_B + m_C}{m_A + m_B + m_C} \right) g \\ &= m_C \left( \frac{m_A}{m_A + m_B + m_C} \right) g = 14 \left( \frac{32}{32 + 44 + 14} \right) 9.8 \\ &= 14 \left( \frac{32}{90} \right) 9.8 = 48.78 \text{ N} \end{aligned}$$

→ B

- C 30. The figure shows sound source  $S$  that is moving in direction of the arrow and four stationary detectors.  $S$  emits a certain frequency. Rank the detectors according to the frequency of the sound they detect from the source, **greatest to least**.



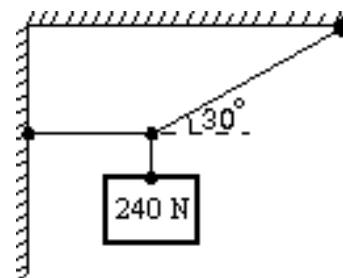
- A.  $2 > 3 > 4 = 1$     B.  $2 > 3 > 4 > 1$     **C.  $1 > 4 > 3 > 2$**     D.  $1 = 4 > 3 > 2$

Doppler effect is larger when the velocity component along the direction toward the detector is larger. Point 1 has larger frequency than point 4. Point 3 has no velocity component toward that point, frequency observed at point 3 is same as the frequency emitted from the source. The source is away from the point 2, the frequency observed at point 2 is lower than the frequency emitted from the source.

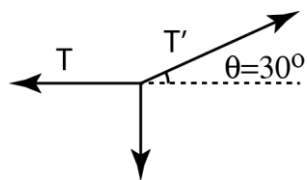
→  $1 > 4 > 3 > 2$

→ C

- B 31. A 240-N weight is hung from two ropes as shown. What is the magnitude of the tension in the horizontal rope?



- A. 176 N  
B. **416 N**  
C. 480 N  
D. 656 N  
E. 720 N



$$W = 240 \text{ N}$$

Both of x and y components of force must be zero since the system is in equilibrium.

$$\text{X: } F_x = T' \cos 30^\circ - T = 0$$

$$\text{Y: } F_y = T' \sin 30^\circ - 240 = 0$$

From the second equation,  $T' = \frac{240}{\sin 30^\circ} = 480$ . Substitute  $T'$  into the first equation,

$$T = T' \cos 30^\circ = \frac{240}{\sin 30^\circ} \cos 30^\circ = \frac{240}{0.5} \times 0.866 = 415.68 \text{ N}$$