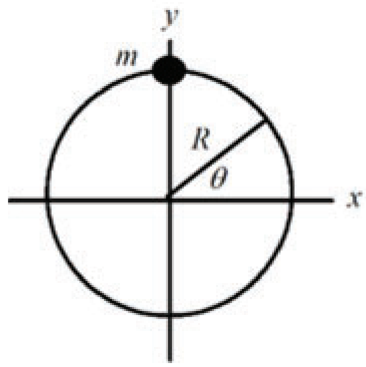
Physics Exam - University of Houston Math Contest
January 29, 2022

Unless otherwise specified, please use g as the acceleration due to gravity at the surface of the earth. Vectors $\hat{\mathbf{x}}$, $\hat{\mathbf{y}}$, and $\hat{\mathbf{z}}$ are unit vectors along x, y, and z, respectively, in a normal Cartesian coordinate system. Let G be the universal gravitational constant. To simplify calculations, you may use $g = 10\,\mathrm{m/s}^2$.

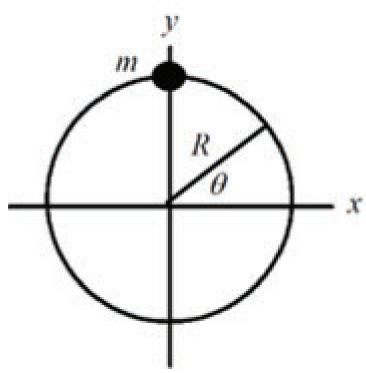
1) Questions 1 - 3 pertain to a mass m that slides on a vertical, circular wire hoop as shown. The top half of the hoop $(0 \leq \theta \leq \pi)$ is friction free, but the bottom half has a kinetic friction coefficient of μ_k. Mass m is released from rest at the top and arrives at point $(R, 0)$ with a velocity $\mathbf{v} = \sqrt{\frac{gR}{2}}\,\hat{\mathbf{y}}$ after traveling in the counter-clockwise direction.



The work done by friction is given by

a) $\dfrac{3mgR}{4}$ b) 0 c) $-\dfrac{3mgR}{4}$ d) $-\dfrac{mgR}{4}$ e) none of the other answers provided

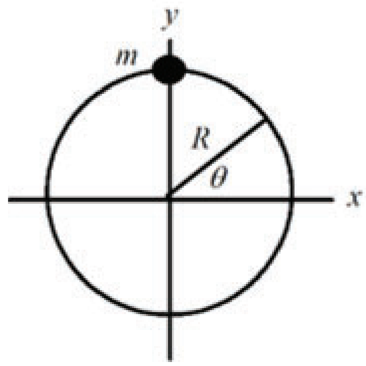
2) Questions 1 - 3 pertain to a mass m that slides on a vertical, circular wire hoop as shown. The top half of the hoop $(0 \leq \theta \leq \pi)$ is friction free, but the bottom half has a kinetic friction coefficient of μ_k. Mass m is released from rest at the top and arrives at point $(R, 0)$ with a velocity $\mathbf{v} = \sqrt{\frac{gR}{2}}\,\hat{\mathbf{y}}$ after traveling in the counter-clockwise direction.



The magnitude of the average force due to friction over the range where friction exists is given by

a) $\dfrac{mg}{4\pi}$ b) $\dfrac{3mg}{2\pi}$ c) $\dfrac{mg}{2\pi}$ d) $\dfrac{3mg}{4\pi}$ e) none of the other answers provided

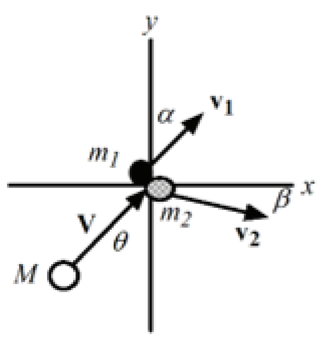
3) Questions 1 - 3 pertain to a mass m that slides on a vertical, circular wire hoop as shown. The top half of the hoop $(0 \leq \theta \leq \pi)$ is friction free, but the bottom half has a kinetic friction coefficient of μ_k. Mass m is released from rest at the top and arrives at point $(R, 0)$ with a velocity $\mathbf{v} = \sqrt{\frac{gR}{2}}\,\hat{\mathbf{y}}$ after traveling in the counter-clockwise direction.



The angle θ that mass m makes with respect to the positive x-axis when it stops is given by

a) $\cos^{-1}\left(\frac{1}{4}\right)$ b) $\sin^{-1}\left(\frac{1}{4}\right)$ c) $\cot^{-1}\left(\frac{1}{4}\right)$ d) $\tan^{-1}\left(\frac{1}{4}\right)$
e) none of the other answers provided

4) Questions 4 - 6 pertain to mass M with velocity $\mathbf{V}$ that makes an angle θ with respect to the negative y-axis as shown. At the origin, mass M breaks into two pieces, m_1 and m_2, that have velocities $\mathbf{v}_1$ and $\mathbf{v}_2$, respectively. $\mathbf{v}_1$ makes angle α with respect to the y-axis, and $\mathbf{v}_2$ makes an angle β with respect to the x-axis. Assume all angles have positive values as shown in the figure. v_1 and v_2 are the magnitudes of the velocities of $\mathbf{v}_1$ and $\mathbf{v}_2$, respectively, and V is the magnitude of the velocity of $\mathbf{V}$.



The symbolic, scalar equation for conservation of momentum in the x-direction, with correct signs, is given by

a) $MV\sin\theta = m_2v_2\cos\beta + m_1v_1\sin\alpha$
b) $MV\sin\theta = m_2v_2\sin\beta + m_1v_1\cos\alpha$
c) $MV\sin\theta = m_2v_2\cos\beta - m_1v_1\sin\alpha$
d) $MV\sin\theta = m_2v_2\sin\beta - m_1v_1\cos\alpha$
e) none of the other answers provided

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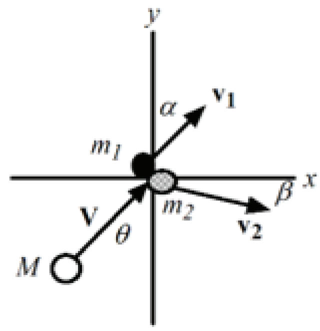
5) Questions 4 - 6 pertain to mass M with velocity $\mathbf{V}$ that makes an angle θ with respect to the negative y-axis as shown. At the origin, mass M breaks into two pieces, m_1 and m_2, that have velocities $\mathbf{v}_1$ and $\mathbf{v}_2$, respectively. $\mathbf{v}_1$ makes angle α with respect to the y-axis, and $\mathbf{v}_2$ makes an angle β with respect to the x-axis. Assume all angles have positive values as shown in the figure. v_1 and v_2 are the magnitudes of the velocities of $\mathbf{v}_1$ and $\mathbf{v}_2$, respectively, and V is the magnitude of the velocity of $\mathbf{V}$.

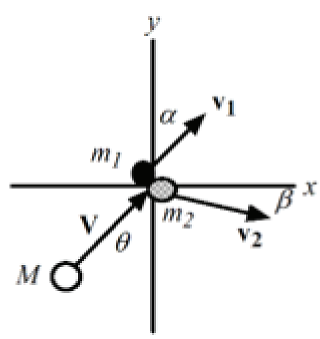


Assume that no mass is lost during the breakup and let $m_1 = 2m_2,\ v_1 = v_2, \sin\alpha = \dfrac{3}{5},$ and $\sin\beta = \dfrac{4}{5}$. The angle θ is given by

a) $\sin^{-1}\left(\dfrac{9}{4}\right)$ b) $\tan^{-1}\left(\dfrac{9}{4}\right)$ c) cannot be determined d) $\cos^{-1}\left(\dfrac{9}{4}\right)$

e) none of the other answers provided

6) Questions 4 - 6 pertain to mass M with velocity $\mathbf{V}$ that makes an angle θ with respect to the negative y-axis as shown. At the origin, mass M breaks into two pieces, m_1 and m_2, that have velocities $\mathbf{v}_1$ and $\mathbf{v}_2$, respectively. $\mathbf{v}_1$ makes angle α with respect to the y-axis, and $\mathbf{v}_2$ makes an angle β with respect to the x-axis. Assume all angles have positive values as shown in the figure. v_1 and v_2 are the magnitudes of the velocities of $\mathbf{v}_1$ and $\mathbf{v}_2$, respectively, and V is the magnitude of the velocity of $\mathbf{V}$.

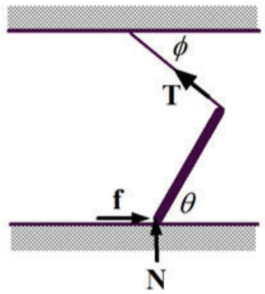


The value for the magnitude V of the velocity $\mathbf{V}$ is given by

a) $\dfrac{20}{3\sqrt{97}}v_2$ b) $\dfrac{15}{\sqrt{97}}v_2$ c) $\dfrac{\sqrt{97}}{15}v_2$ d) $\dfrac{3\sqrt{97}}{20}v_2$

e) cannot be determined f) none of the other answers provided

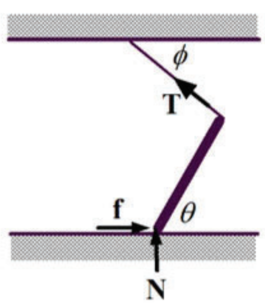
7) Questions 7 - 9 pertain to a student studying torque using a configuration that is shown in the figure below. A uniform bar having mass M is attached to a ceiling with a string having tension T, and the bottom of the bar rests on the floor that produces a coefficient of static friction between the floor and the bar given by μ_s. The length of the bar is L, f is the magnitude of the static frictional force, and N is the magnitude of the normal force of contact between the bar and the floor. The angles θ and ϕ are shown in the figure. You wish to determine the relationships between the different variables using the equations that describe static equilibrium. Use a standard coordinate system with $+x$ to the right and $+y$ up the page, and consider all angles positive as shown.



Expressions for f are given by

a) $f = T\cos\phi$ only   b) $f = T\cos\phi,\ f > \mu_s N$ c) $f = T\cos\phi,\ f < \mu_s N$
d) $f = T\cos\phi,\ f = \mu_s N$ e) none of the other answers provided

8) Questions 7 - 9 pertain to a student studying torque using a configuration that is shown in the figure below. A uniform bar having mass M is attached to a ceiling with a string having tension T, and the bottom of the bar rests on the floor that produces a coefficient of static friction between the floor and the bar given by μ_s. The length of the bar is L, f is the magnitude of the static frictional force, and N is the magnitude of the normal force of contact between the bar and the floor. The angles θ and ϕ are shown in the figure. You wish to determine the relationships between the different variables using the equations that describe static equilibrium. Use a standard coordinate system with $+x$ to the right and $+y$ up the page, and consider all angles positive as shown.

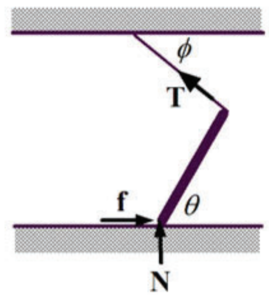


An expression for N is given by

a) $N = Mg - T\sin\phi$ b) $N = Mg + T\sin\phi$ c) $N = Mg$ d) $N = -Mg + T\sin\phi$

e) none of the other answers provided

9) Questions 7 - 9 pertain to a student studying torque using a configuration that is shown in the figure below. A uniform bar having mass M is attached to a ceiling with a string having tension T, and the bottom of the bar rests on the floor that produces a coefficient of static friction between the floor and the bar given by μ_s. The length of the bar is L, f is the magnitude of the static frictional force, and N is the magnitude of the normal force of contact between the bar and the floor. The angles θ and ϕ are shown in the figure. You wish to determine the relationships between the different variables using the equations that describe static equilibrium. Use a standard coordinate system with $+x$ to the right and $+y$ up the page, and consider all angles positive as shown.

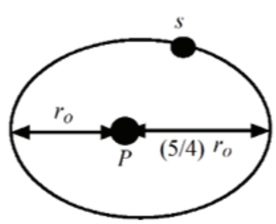


An expression for M is given by

a) $M = \dfrac{2T\sin(\theta+\phi)}{g\sin\theta}$ b) $M = \dfrac{2T\cos(\theta+\phi)}{g\sin\theta}$ c) $M = \dfrac{T\sin(\theta+\phi)}{g\sin\theta}$

d) $M = \dfrac{2T\cos(\theta+\phi)}{g\cos\theta}$ e) none of the other answers provided

10) Questions 10 - 12 pertain to a satellite s having mass m revolving around a planet P having mass M. Assume $M \gg m$ and assume that the planet is stationary. The satellite's distance of closest approach to the planet is r_0, and its farthest distance from the planet is $\frac{5}{4}r_0$.



The ratio of the satellite's kinetic energy K_2 at $\frac{5}{4}r_0$ to its kinetic energy K_1 at r_0 is given by

a) $\dfrac{4}{5}$ b) $\dfrac{16}{25}$ c) $\dfrac{25}{16}$ d) $\dfrac{5}{4}$ e) none of the other answers provided

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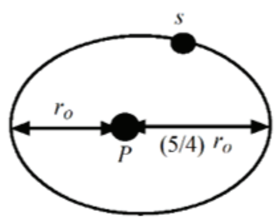
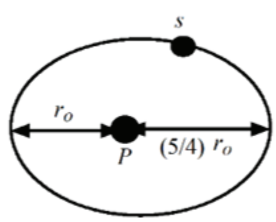
11) Questions 10 - 12 pertain to a satellite s having mass m revolving around a planet P having mass M. Assume $M \gg m$ and assume that the planet is stationary. The satellite's distance of closest approach to the planet is r_0 , and its farthest distance from the planet is $\frac{5}{4}r_0$.



We know that that the planet's motion lies in a plane because

a) potential energy is conserved
b) kinetic energy is conserved
c) linear momentum is conserved
d) total energy is conserved
e) none of the other answers provided

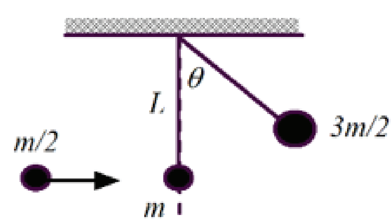
12) Questions 10 - 12 pertain to a satellite s having mass m revolving around a planet P having mass M. Assume $M \gg m$ and assume that the planet is stationary. The satellite's distance of closest approach to the planet is r_0 , and its farthest distance from the planet is $\frac{5}{4}r_0$.



As the satellite revolves around the planet, the center of mass of the system

a) moves outside the orbit indicated in the figure
b) moves in a circle around mass M
c) cannot be determined
d) remains at rest because the system is isolated
e) none of the other answers provided

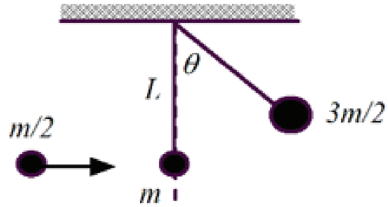
13) Questions 13 - 15 pertain to a mass m that is attached to a string having a length L as shown. Mass m is initially at rest when it is struck by a projectile having mass $m/2$ and speed v_0 to the right. Mass $m/2$ becomes embedded in mass m.



The height to which mass $\frac{3m}{2}$ rises before coming to rest is given by

a) $\frac{v_0^2}{9g}$ b) $\frac{v_0^2}{18g}$ c) $\frac{v_0^2}{6g}$ d) $\frac{v_0^2}{3g}$
e) none of the other answers provided

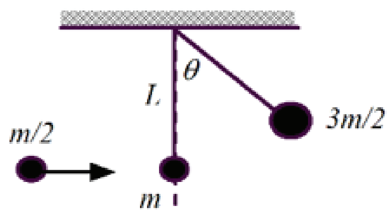
14) Questions 13 - 15 pertain to a mass m that is attached to a string having a length L as shown. Mass m is initially at rest when it is struck by a projectile having mass $m/2$ and speed v_0 to the right. Mass $m/2$ becomes embedded in mass m.



The tension in the string when mass $\frac{3m}{2}$ arrives back at the bottom is given by

a) $\frac{3}{2}m\left(g-\frac{v_0^2}{9L}\right)$ b) 0 c) $\frac{3}{2}mg$ d) $\frac{3}{2}m\left(g+\frac{v_0^2}{9L}\right)$ e) none of the other answers provided

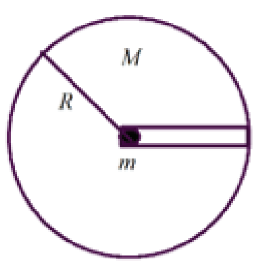
15) Questions 13 - 15 pertain to a mass m that is attached to a string having a length L as shown. Mass m is initially at rest when it is struck by a projectile having mass $m/2$ and speed v_0 to the right. Mass $m/2$ becomes embedded in mass m.



From the time of the collision, the time required for the mass to return to the bottom traveling to the left is given by

a) $\pi\left(\frac{L}{g}\right)$ b) $2\pi\sqrt{\frac{L}{g}}$ c) $2\pi\sqrt{\frac{g}{L}}$ d) $\pi\sqrt{\frac{g}{L}}$ e) none of the other answers provided

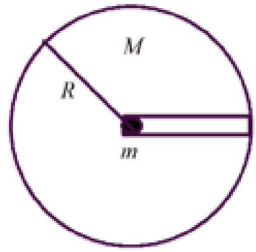
16) Questions 16 - 18 pertain to the figure below that shows the top view of a disk having mass M and moment of inertia $\frac{1}{2}MR^2$. A small mass m can be placed at its center and slide along the groove as shown. Initially, the disk spins with an angular velocity ω_0 when mass m is placed at its center and slides out to the edge where it sticks to the wall. The time required for the mass to slide the distance R is t. Let $m=\frac{M}{4}$ and assume its size is negligible.



After m reaches the edge, the angular velocity ω_f of the system is given by

a) $\omega_f=\frac{4}{9}\omega_0$ b) $\omega_f=\frac{4}{5}\omega_0$ c) $\omega_f=\frac{9}{4}\omega_0$ d) $\omega_f=\frac{3}{2}\omega_0$
e) none of the other answers provided

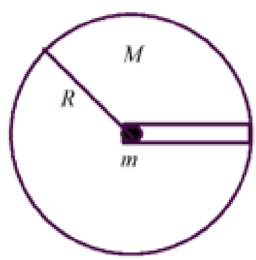
17) Questions 16 - 18 pertain to the figure below that shows the top view of a disk having mass M and moment of inertia $\frac{1}{2}MR^2$. A small mass m can be placed at its center and slide along the groove as shown. Initially, the disk spins with an angular velocity ω_0 when mass m is placed at its center and slides out to the edge where it sticks to the wall. The time required for the mass to slide the distance R is t. Let $m = \frac{M}{4}$ and assume its size is negligible.



The fractional change in the kinetic energy of the system is given by

a) $-\frac{1}{6}$ b) $-\frac{1}{3}$ c) $-\frac{1}{12}$ d) $-\frac{1}{4}$ e) none of the other answers provided

18) Questions 16 - 18 pertain to the figure below that shows the top view of a disk having mass M and moment of inertia $\frac{1}{2}MR^2$. A small mass m can be placed at its center and slide along the groove as shown. Initially, the disk spins with an angular velocity ω_0 when mass m is placed at its center and slides out to the edge where it sticks to the wall. The time required for the mass to slide the distance R is t. Let $m = \frac{M}{4}$ and assume its size is negligible.



The magnitude of the average torque exerted on the disk during the process is given by

a) $\frac{mR^2\omega_0}{2t}$ b) $\frac{2mR^2\omega_0}{5t}$ c) $\frac{mR^2\omega_0}{3t}$ d) $\frac{2mR^2\omega_0}{3t}$ e) none of the other answers provided

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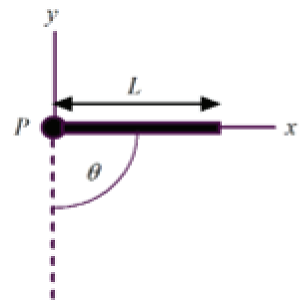
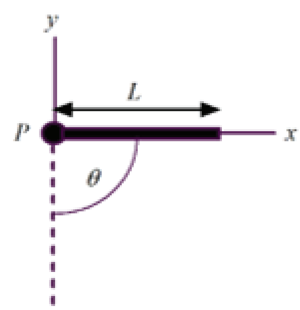
19) Questions 19 - 21 pertain to a rod of length L, mass m, and moment of inertia I that is suspended from a pivot and allowed to swing from rest as shown in the figure. At any arbitrary angle θ, measured counter-clockwise from the dashed line, the magnitude of the angular velocity of the rod is ω_θ. The center of mass of the rod is located at $\frac{2}{3}L$ as measured from the pivot.



The vector expression for the angular velocity $\boldsymbol{\omega}$ is given by

a) $\boldsymbol{\omega} = -\omega_\theta \hat{\mathbf{x}}$ b) $\boldsymbol{\omega} = \omega_\theta \hat{\mathbf{x}}$ c) $\boldsymbol{\omega} = \omega_\theta \hat{\mathbf{z}}$ d) $\boldsymbol{\omega} = \omega_\theta \hat{\mathbf{y}}$ e) none of the other answers provided

20) Questions 19 - 21 pertain to a rod of length L, mass m, and moment of inertia I that is suspended from a pivot and allowed to swing from rest as shown in the figure. At any arbitrary angle θ, measured counter-clockwise from the dashed line, the magnitude of the angular velocity of the rod is ω_θ. The center of mass of the rod is located at $\frac{2}{3}L$ as measured from the pivot.



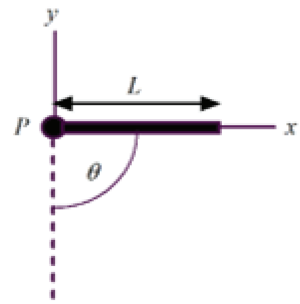
When $\theta = sin^{-1}\left(\frac{1}{2}\right)$, the vector expression for the linear velocity $\mathbf{v}$ of the center of mass is given by

a) $\mathbf{v} = -\hat{\mathbf{x}}\left(\frac{1}{3}\omega_\theta L\right) - \hat{\mathbf{y}}\left(\frac{\sqrt{3}}{3}\omega_\theta L\right)$ b) $\mathbf{v} = -\hat{\mathbf{x}}\left(\frac{\sqrt{3}}{3}\omega_\theta L\right) - \hat{\mathbf{y}}\left(\frac{1}{3}\omega_\theta L\right)$

c) $\mathbf{v} = -\hat{\mathbf{x}}\left(\frac{\sqrt{3}}{2}\omega_\theta L\right) - \hat{\mathbf{y}}\left(\frac{1}{2}\omega_\theta L\right)$ d) $\mathbf{v} = -\hat{\mathbf{x}}\left(\frac{1}{2}\omega_\theta L\right) - \hat{\mathbf{y}}\left(\frac{\sqrt{3}}{2}\omega_\theta L\right)$

e) none of the other answers provided

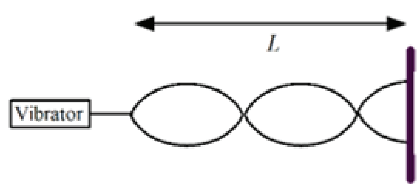
21) Questions 19 - 21 pertain to a rod of length L, mass m, and moment of inertia I that is suspended from a pivot and allowed to swing from rest as shown in the figure. At any arbitrary angle θ, measured counter-clockwise from the dashed line, the magnitude of the angular velocity of the rod is ω_θ. The center of mass of the rod is located at $\frac{2}{3}L$ as measured from the pivot.



The vector expression for the angular acceleration $\boldsymbol{\alpha}$ at arbitrary θ is given by

a) $\boldsymbol{\alpha} = \frac{2mgL}{3I}\sin\theta\,\hat{\mathbf{z}}$ b) $\boldsymbol{\alpha} = -\frac{2mgL}{3I}\sin\theta\,\hat{\mathbf{z}}$ c) $\boldsymbol{\alpha} = \frac{2mgL}{3I}\cos\theta\,\hat{\mathbf{z}}$ d) $\boldsymbol{\alpha} = -\frac{2mgL}{3I}\cos\theta\,\hat{\mathbf{z}}$
e) none of the other answers provided

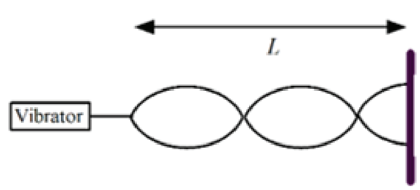
22) Questions 22 - 23 pertain to a string that is stretched between two supports. The tension in the string is T, the length of the string is L, and the speed of a wave on the string is v_0. The linear mass density of the string is d. One of the supports is a vibrator that can vibrate with frequency f causing a standing wave to be set up as shown. The other end is attached to a massless ring that can slide friction free on a rod so that the angle between that rod and the string is 90 degrees.



The frequency that causes this standing wave is given by

a) $\frac{3v_0}{2L}$ b) $\frac{v_0}{L}$ c) $\frac{3v_0}{4L}$ d) $\frac{5v_0}{4L}$ e) none of the other answers provided

23) Questions 22 - 23 pertain to a string that is stretched between two supports. The tension in the string is T, the length of the string is L, and the speed of a wave on the string is v_0. The linear mass density of the string is d. One of the supports is a vibrator that can vibrate with frequency f causing a standing wave to be set up as shown. The other end is attached to a massless ring that can slide friction free on a rod so that the angle between that rod and the string is 90 degrees.



If the linear mass density changes to $\frac{3}{4}d$ and no other parameters change, then in order to keep the same standing wave pattern, the frequency becomes
a) $\frac{5v_0}{8L}$ b) $\frac{5v_0}{2L}$ c) $\frac{5v_0}{3L}$ d) $\frac{5v_0}{4L}$ e) none of the other answers provided

24) An object initially at rest is subjected to a constant net force. Measurements are taken of its velocity v at different distances d from the starting position. A graph of which of the following should exhibit a straight-line relationship?

a) d versus v^{-1} b) d^2 versus v^{-2} c) d^2 versus v^2 d) d versus v^2
e) none of the other answers provided

25) In which of the following situations would an object be accelerated?

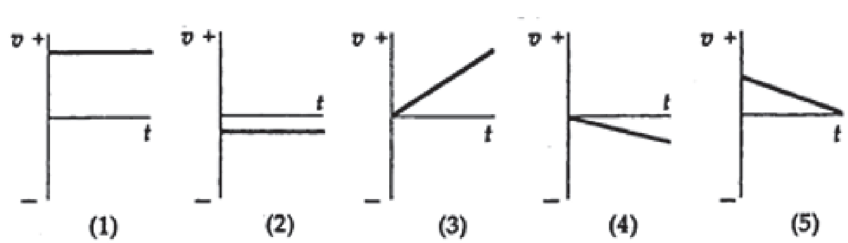
I. It moves in a straight line at constant speed.
II. It moves with uniform circular motion.
III. It travels as a projectile in a gravitational field with negligible air resistance.

a) I only b) II and III only c) I, II and III d) III only e) none of the other answers provided

26) An object is released from rest on a planet that has no atmosphere. The object falls freely for 4.0 meters in the first second. What is the magnitude of the acceleration due to gravity on the planet?

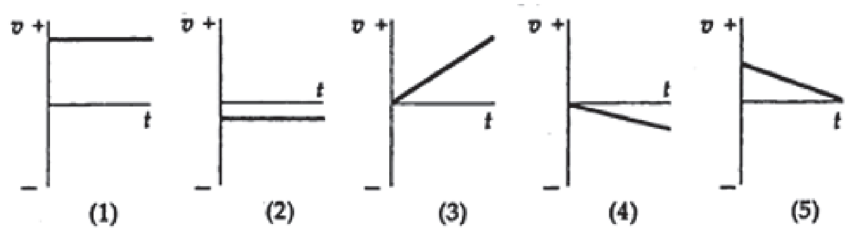
a) $4\,m/s^2$ b) $2\,m/s^2$ c) $8\,m/s^2$ d) $10\,m/s^2$ e) none of the other answers provided

27) In which graph of v vs. t does the object end up farthest from its starting point?



a) 1 b) 2 c) 3 d) 4 e) 5

28) Which graph of v vs. t best describes the motion of a particle with positive velocity and negative acceleration?

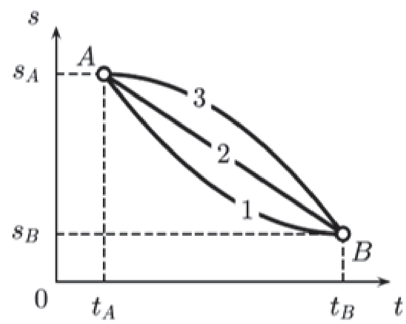


a) 1 b) 2 c) 3 d) 4 e) 5

29) A car and a truck, starting from rest, have the same acceleration, but the truck accelerates for one/half the length of time. We wish to compare the distance traveled while accelerating. Compared with the car, the truck will travel

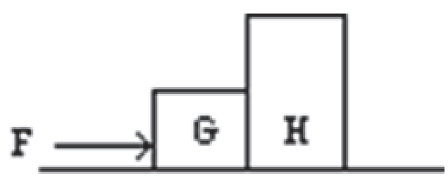
a) twice as far b) four times as far c) one-half as far d) one-fourth as far
e) none of the other answers provided

30) Consider three position curves between time points A and B. Choose the correct relationship among the average velocities, $v_{1\text{ avg}}$, $v_{2\text{ avg}}$, and $v_{3\text{ avg}}$.



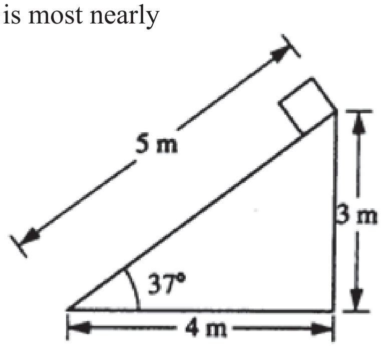
a) $v_{1\text{ avg}} > v_{2\text{ avg}} > v_{3\text{ avg}}$ b) $v_{1\text{ avg}} = v_{2\text{ avg}} = v_{3\text{ avg}}$ c) $v_{2\text{ avg}} > v_{1\text{ avg}} = v_{3\text{ avg}}$
d) $v_{1\text{ avg}} < v_{2\text{ avg}} < v_{3\text{ avg}}$ e) none of the other answers provided

31) Two cardboard boxes full of books are in contact with each other on a frictionless table. Box H has twice the mass of box G. If you push on box G with a horizontal force F, then box H will experience a net force of



a) F/3 b) 2/3 F c) 2 F d) 3/2 F e) none of the other answers provided

32) A plane 5 meters in length is inclined at an angle of 37°, as shown above. A block of weight 30 newtons is placed at the top of the plane and allowed to slide down. The work done on the block by the gravitational force during the 5 meter slide down the plane is most nearly

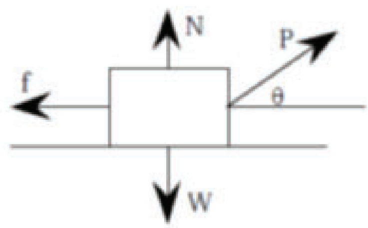


a) 150 J b) 30 J c) 120 J d) 90 J e) none of the other answers provided

33) A rock is dropped from the top of a large building. One second later, another rock with twice the mass as the first is dropped from the top of the same building. Ignoring air resistance, which of the following statements is true?

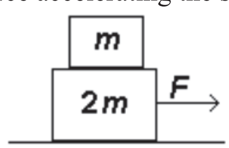
a) They strike the ground with the same kinetic energy.
b) They strike the ground more than one second apart.
c) The distance between the rocks increases while both are falling.
d) The acceleration is greater for the more massive rock.
e) none of the other answers provided

34) A physics student pulls a mass along a rough horizontal floor at a constant speed with a force of P as shown in the diagram. Which of the following must be true?



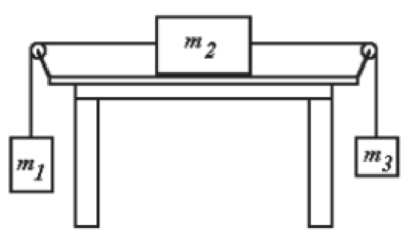
a) $P = f$ and $N > W$ b) $P > f$ and $N = W$ c) $P > f$ and $N < W$
d) $P = f$ and $N = W$ e) none of the other answers provided

35) A small box of mass m is placed on a larger box of mass $2m$ as shown in the diagram. When a force F is applied to the larger box, both boxes accelerate to the right with the same acceleration. If the coefficient of friction between all surfaces is μ, what would be the force accelerating the smaller mass?



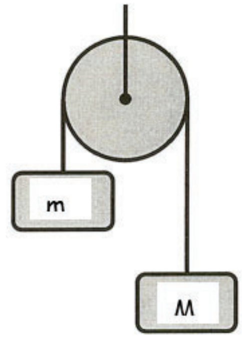
a) $F - 3mg\mu$ b) $\dfrac{Fmg\mu}{3}$ c) $F - mg\mu$ d) $\dfrac{F}{3} - mg\mu$ e) none of the other answers provided

36) Three masses are shown in the diagram. If the coefficient of kinetic friction between m_2 and the table is μ, what is the upward acceleration of m_3? Note that $m_2 > m_1 > m_3$ and the mass and friction of the cords and pulleys are negligible.



a) $\dfrac{g(m_1 + \mu m_2)}{m_1 + m_2 + m_3}$ b) $\dfrac{g(m_1 - \mu m_2 - m_3)}{m_1 + m_2 + m_3}$ c) $\dfrac{g\mu(m_1 - m_2 - m_3)}{m_1 + m_2 + m_3}$
d) $\dfrac{g\mu(m_1 + m_2 + m_3)}{m_1 - \mu m_2 - m_3}$ e) none of the other answers provided

37) Assuming a frictionless, massless pulley, determine the acceleration of the blocks once they are released from rest if $M > m$.



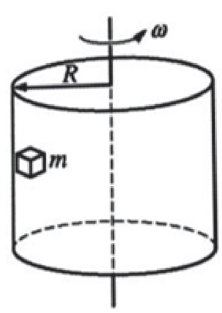
a) $\dfrac{Mg}{M+m}$ b) $\dfrac{(M+m)g}{M-m}$ c) $\dfrac{(M-m)g}{M+m}$ d) $\dfrac{Mg}{m}$ e) $\dfrac{mg}{M+m}$
f) none of the other answers provided

38) A projectile is launched at an angle of 60° with a velocity of $200\,m/s$. If air resistance is negligible, what is the magnitude of the horizontal velocity of the projectile when it reaches maximum altitude?
a) $200\,m/s$ b) $125\,m/s$ c) $100\,m/s$ d) $250\,m/s$ e) none of the other answers provided

39) A projectile is launched over level ground with a horizontal component of velocity of $v_x = 40\,m/s$ and a vertical component of velocity of $v_y = 50\,m/s$. At what horizontal distance from the launch point will the projectile strike the ground?

a) $200\,m$ b) $400\,m$ c) $250\,m$ d) $500\,m$ e) none of the other answers provided

40) **TIEBREAKER QUESTION:** A block of mass m is placed against the inner wall of a hollow cylinder of radius R that rotates about a vertical axis with a constant angular velocity, ω, as shown. In order for friction to prevent the mass from sliding down the wall, the coefficient of static friction μ between the mass and the wall must satisfy which of the following inequalities?



a) $\mu \le \dfrac{\omega^2 R}{g}$ b) $\mu \le mg$ c) $\mu \ge \dfrac{g}{\omega^2 R}$ d) $\mu \le \dfrac{g}{\omega^2 R}$ e) $\mu \ge \dfrac{\omega^2 R}{g}$
f) none of the other answers provided