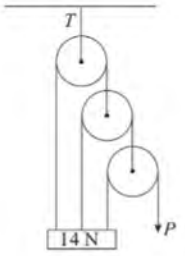
9. The pull $P$ is just sufficient to keep the 14-N block and the weightless pulleys in equilibrium as shown. The tension $T$ in the upper cable is:

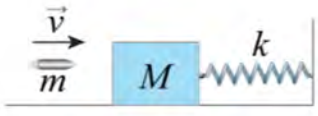



(1) 16 N
(2) 14 N
(3) 28 N
(4) 9.33 N
(5) 18.7 N

4. A rabbit is dashing through the forest. Its position as a function of time is given by $\vec{r}(t) = (3-5t)\hat{i} + (3t^2 - 2t^3)\hat{j}$, where position is measured in meters and time in seconds. What is the magnitude of the rabbit's acceleration (in m/s$^2$) at $t = 1$ s?

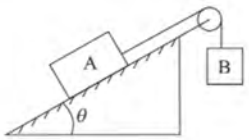
(1) 6 (2) 18 (3) 24 (4) 2 (5) 32

14. A block of mass $M = 5.4$ kg at rest on a horizontal frictionless table, is attached to a rigid support by a spring of constant $k = 6000\,\text{N/m}$. A bullet of mass $m = 9.5\,\text{g}$ and velocity $\vec{v}$ of magnitude 630 m/s strikes and is embedded in the block. Assuming the compression of the spring is negligible until the bullet is embedded, determine the amplitude of the resulting simple harmonic oscillation?




(1) 3.3 cm (2) 2.5 cm (3) 4.6 cm (4) 5.2 cm (5) 6.0 cm

3. Block A, with a mass of 5.0 kg, rests on a $\theta = 30°$ incline. The coefficient of kinetic friction is 0.10. The attached string is parallel to the incline and passes over a massless, frictionless pulley at the top. Block B, with a mass of 4.0 kg, is attached to the dangling end of the string. The acceleration of B is:




(1) 1.2 m/s$^2$, down (2) 1.2 m/s$^2$, up (3) 4.4 m/s$^2$, down (4) 4.4 m/s$^2$, up (5) 0

6. The potential energy of a 0.20-kg particle moving along the $x$ axis is given by $U(x) = 8x^2 - 2x^4$, where $U$ is in joules and $x$ is in meters. When the particle is at $x = 1.0$ m, its acceleration is:

(1) $-40$ m/s$^2$ (2) 0 (3) $-8$ m/s$^2$ (4) 8 m/s$^2$ (5) 40 m/s$^2$

19. A source emits sound with a frequency of 1000 Hz. It is moving at 20 m/s toward a reflecting wall. If the speed of sound is 340 m/s, an observer at rest directly behind the source hears a beat frequency of:

(1) 118 Hz (2) 11 Hz (3) 86 Hz (4) 97 Hz (5) 183 Hz

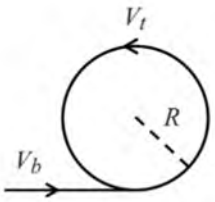
3. The density of a particular grade of steel is 7900 kg/m$^3$. A cube of this steel has 10.0 cm side lengths but is *missing* a cubical *interior* volume with 4.00 cm side lengths. The apparent weight of the block under water (density 1000 kg/m$^3$) is (in N):

(1) 62.7 (2) 65.5 (3) 57.9 (4) 50.9 (5) 53.2

19. While driving at a constant speed of 12 m/s around a traffic circle having a radius of 45 m, a small mass dangling by a string from your rear view mirror would hang at an angle with respect to the vertical (in degrees) of:

(1) 18 (2) 21 (3) 24 (4) 14 (5) 26

25. A roller coaster is to go through a vertical loop as shown. What is the minimum speed (in m/s) at the bottom of the loop ($V_b$) necessary so that the cars do not fall off of the track at the top of the loop if the radius of the loop is $R = 7.00$ m? Treat a roller coaster car as a point mass going through the loop.

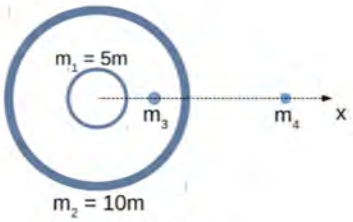



(1) 18.5 (2) 19.8 (3) 21.0 (4) 22.1 (5) 23.2

9. A bomb at rest explodes into two fragments, one of mass $m_1$ and one of mass $m_2$, that travel in opposite directions. What is the ratio of the kinetic energy of the fragment of mass $m_1$ to the kinetic energy of the fragment of mass $m_2$?

(1) $m_2/m_1$ (2) $m_1/m_2$ (3) $m_2^2/m_1^2$ (4) $m_1^2/m_2^2$ (5) 1

14. Four spherical masses are arranged with their centers on the $x$-axis. Masses $m_1$ and $m_2$ are spherical shells with their centers located at $x = 0$. The radius of $m_1$ is 50 km and the radius of $m_2$ is 120 km. Mass $m_3$ is located at $x = 80$ km and mass $m_4$ is located at $x = 320$ km. What is the mass of $m_4$ such that the net force on $m_3$ is zero?




(1) $45m$ (2) 0 (3) $135m$ (4) $50m$ (5) $15m$

2. A small coin rests on a table. The table turns around its center at a constant rate. The distance between the coin and the center of the table is 20 cm. The coefficient of static friction between the coin and the table is 0.5. What is the maximum angular velocity of the table for which the coin does not slide?


(1) 4.9 rad/s
(2) 14 rad/s
(3) 49 rad/s
(4) 0.7 rad/s
(5) 1.4 rad/s

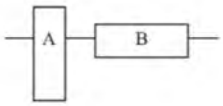
9. A playground merry-go-round has a radius $R$ and rotational inertia $I$. When the merry-go-round is at rest, a child with mass $m$ runs towards the merry-go-round with speed $v$ along a line tangent to the rim and jumps on it. The angular velocity of the merry-go-round is then:

(1) $mRv/(mR^2 + I)$ (2) $v/R$ (3) $mRv/I$ (4) $2mRvI$ (5) $mv/I$

10. A 5.0 g bullet moving at speed $v$ strikes a 500 g wooden block at rest on a frictionless surface. The bullet emerges, traveling in the same direction with its speed reduced to $v/2$. What is the resulting speed of the block?

(1) $v/200$ (2) $v/100$ (3) $v/500$ (4) $v/2$ (5) $v/50$

13. Two identical blocks of ice float in water as shown. Then:

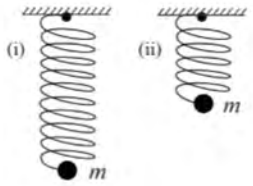



(1) the two blocks displace equal volumes of water since they have the same weight.
(2) block B displaces a greater volume of water since the pressure is less on its bottom.
(3) block A displaces a greater volume of water since the pressure acts on a smaller bottom area.
(4) block A displaces a greater volume of water since its submerged end is lower in the water.
(5) block B displaces a greater volume of water since its submerged end has a greater area.

15. A block attached to a spring undergoes simple harmonic motion on a horizontal frictionless surface. Its total energy is 50.0 J. When the displacement is half the amplitude, the kinetic energy is:

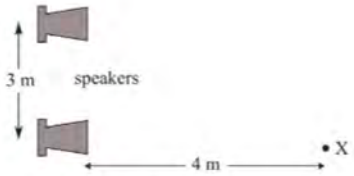
(1) 37.5 J (2) 12.5 J (3) 25.0 J (4) zero (5) 50.0 J

15. A simple harmonic oscillator consists of a mass and spring $(m, k)$. It oscillates as shown in (i) with period $T$. If the spring is cut in half and used with the same mass $m$, as shown in (ii), the period will be:



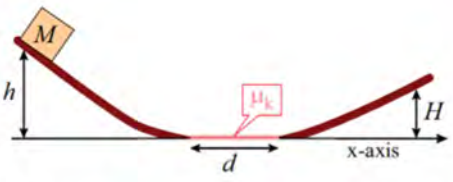

(1) $T/\sqrt{2}$
(2) $2T$
(3) $\sqrt{2}T$
(4) $T$
(5) $T/2$

19. Two small identical speakers are connected (in phase) to the same source. The speakers are 3 m apart and at ear level. An observer stands at X, 4 m in front of one speaker, as shown. The sound he hears will be least intense if the wavelength is:




(1) 2 m (2) 5 m (3) 4 m (4) 3 m (5) 1 m

13. Near the surface of the Earth a block of mass $M$ is released from rest at a height $h$ on a frictionless incline as shown in the figure. The block slides down the frictionless incline to reach a flat horizontal surface with a kinetic coefficient of friction $\mu_k = 0.5$. The block slides a horizontal distance $d$ and then slides up a frictionless incline and reaches a maximum height $H$ before sliding back down. If $h = d$, what is $H$?

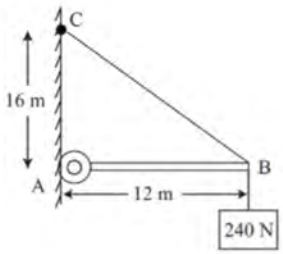



(1) $h/2$ (2) $3h/4$ (3) $h/4$ (4) $h$ (5) $h/3$

35. Planet Roton, with a mass of $7 \times 10^{24}$ kg and a radius of 3,000 km, gravitationally attracts a meteorite that is initially at rest relative to the planet, at a distance great enough to take as infinite. The meteorite falls toward the planet. Assuming the planet is airless, what is the speed (in km/s) of the meteorite relative to the planet when it reaches the planet's surface?

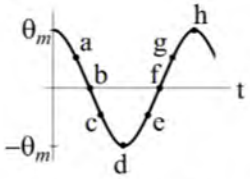
(1) 17.6 (2) 25.0 (3) 14.4 (4) 31.2 (5) 11.6

10. A 240-N block is suspended as shown. The beam AB is weightless and is hinged to the wall at A. The tension in the cable BC is:




(1) 300 N
(2) 400 N
(3) 320 N
(4) 180 N
(5) 240 N

8. The figure plots the angular displacement for a torsion pendulum undergoing simple harmonic oscillations: $\theta = \theta_m \cos\left(\sqrt{\frac{\kappa}{I}}t\right)$. Referring to the labeled points on the plot, the magnitude of the angular acceleration is greatest at:




(1) d and h (2) a and c (3) b and f (4) e and g (5) a, c, e, and g