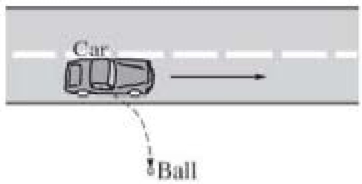
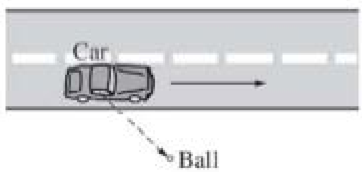
Problem 1:

A ball is thrown out of the passenger window of a car moving to the right (ignore air resistance). If the ball is thrown out perpendicular to the velocity of the car, which of the following best depicts the path the ball takes, as viewed from above?

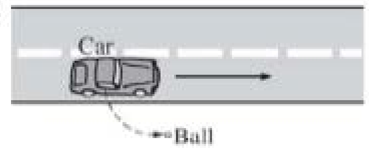
(A)



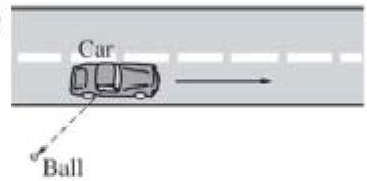
(B)



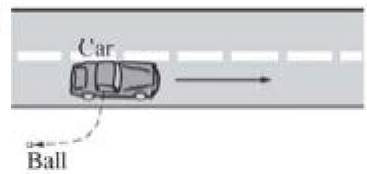
(C)



(D)



(E)



Problem 2:

An object is thrown horizontally from the open window of a building. If the initial speed of the object is 20 m/s and it hits the ground 2.0 s later, from what height was it thrown? (Neglect air resistance and assume the ground is level.)

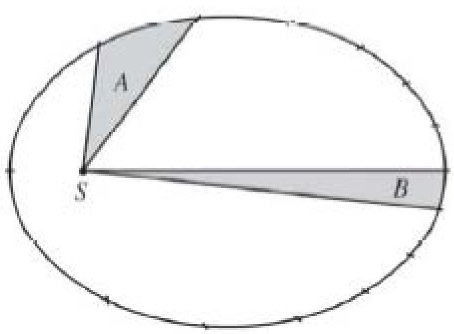
(A) 4.9 m
(B) 9.8 m
(C) 10.0 m
(D) 19.6 m
(E) 39.2 m

Problem 3:

A spring of force constant k is stretched a certain distance. It takes twice as much work to stretch a second spring by half this distance. The force constant of the second spring is

(A) k
(B) $2k$
(C) $4k$
(D) $8k$
(E) $16k$

Problem 4:



. The figure above represents the orbit of a planet around a star, S, and the marks divide the orbit into 14 equal time intervals, $t = T/14$, where T is the orbital period. If the only force acting on the planet is Newtonian gravitation, then true statements about the situation include which of the following?

I. Area A = area B
II. The star S is at one focus of an elliptically shaped orbit.
III. $T^2 = Ca^3$, where a is the semimajor axis of the ellipse and C is a constant.

(A) I only
(B) II only
(C) I and II only
(D) II and III only
(E) I, II, and III

Problem 5:

A massless spring with force constant k launches a ball of mass m. In order for the ball to reach a speed v, by what displacement s should the spring be compressed?

(A) $s = v\sqrt{\frac{k}{m}}$

(B) $s = v\sqrt{\frac{m}{k}}$

(C) $s = v\sqrt{\frac{2k}{m}}$

(D) $s = v\frac{m}{k}$

(E) $s = v^2\frac{m}{2k}$

Problem 6:

On a frictionless surface, a block of mass M moving at speed v collides elastically with another block of the same mass that is initially at rest. After the collision, the first block moves at an angle θ to its initial direction and has a speed $v/2$. The second block's speed after the collision is

(A) $\frac{\sqrt{3}}{4}v$

(B) $\frac{v}{2}$

(C) $\frac{\sqrt{3}}{2}v$

(D) $\frac{\sqrt{5}}{2}v$

(E) $v + \frac{v}{2}\cos\theta$

Problem 7:

Astronomers observe two separate solar systems, each consisting of a planet orbiting a sun. The two orbits are circular and have the same radius R. It is determined that the planets have angular momenta of the same magnitude L about their suns, and that the orbital periods are in the ratio of three to one; i.e., $T_1 = 3T_2$. The ratio m_1/m_2 of the masses of the two planets is

(A) 1

(B) $\sqrt{3}$

(C) 2

(D) 3

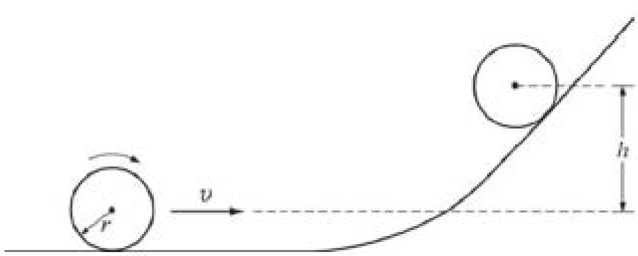
(E) 9

Problem 8:

If the Sun were suddenly replaced by a black hole of the same mass, it would have a Schwarzschild radius of 3,000 m. What effect, if any, would this change have on the orbits of the planets?

(A) The planets would move directly toward the Sun.
(B) The planets would move in spiral orbits.
(C) The planets would oscillate about their former elliptical orbits.
(D) The orbits would precess much more rapidly.
(E) The orbits would remain unchanged.

Problem 9:



A uniform disk with a mass of m and a radius of r rolls without slipping along a horizontal surface and ramp, as shown above. The disk has an initial velocity of v. What is the maximum height h to which the center of mass of the disk rises?

(A) $h = \frac{v^2}{2g}$

(B) $h = \frac{3v^2}{4g}$

(C) $h = \frac{v^2}{g}$

(D) $h = \frac{3v^2}{2g}$

(E) $h = \frac{2v^2}{g}$

Problem 10:

A small plane can fly at a speed of 200 km/h in still air. A 30 km/h wind is blowing from west to east. How much time is required for the plane to fly 500 km due north?

(A) $\frac{50}{23}$ h

(B) $\frac{50}{\sqrt{409}}$ h

(C) $\frac{50}{20}$ h

(D) $\frac{50}{\sqrt{391}}$ h

(E) $\frac{50}{17}$ h

Problem 11:

A 1 kg block attached to a spring vibrates with a frequency of 1 Hz on a frictionless horizontal table. Two springs identical to the original spring are attached in parallel to an 8 kg block placed on the same table. Which of the following gives the frequency of vibration of the 8 kg block?

(A) $\frac{1}{4}$ Hz

(B) $\frac{1}{2\sqrt{2}}$ Hz

(C) $\frac{1}{2}$ Hz

(D) 1 Hz

(E) 2 Hz

Problem 12:

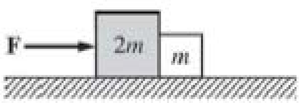


Figure 1

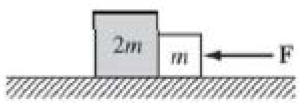
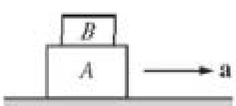


Figure 2

Each of the figures above shows blocks of mass $2m$ and m acted on by an external horizontal force **F**. For each figure, which of the following statements about the magnitude of the force that one block exerts on the other (F_{12}) is correct? (Assume that the surface on which the blocks move is frictionless.)

	Figure 1	Figure 2
(A)	$F_{12} = \frac{F}{3}$	$F_{12} = \frac{F}{3}$
(B)	$F_{12} = \frac{F}{3}$	$F_{12} = \frac{2F}{3}$
(C)	$F_{12} = \frac{2F}{3}$	$F_{12} = \frac{F}{3}$
(D)	$F_{12} = \frac{2F}{3}$	$F_{12} = \frac{2F}{3}$
(E)	$F_{12} = F$	$F_{12} = F$

Problem 13:



In the figure above, block A has mass $m_A = 25$ kg and block B has mass $m_B = 10$ kg. Both blocks move with constant acceleration $a = 2\ \text{m/s}^2$ to the right, and the coefficient of static friction between the two blocks is $\mu_s = 0.8$. The static frictional force acting between the blocks is

(A) 20 N
(B) 50 N
(C) 78 N
(D) 196 N
(E) 274 N

Problem 14:

A simple pendulum of length l is suspended from the ceiling of an elevator that is accelerating upward with constant acceleration a. For small oscillations, the period, T, of the pendulum is

(A) $T = 2\pi\sqrt{\frac{l}{g}}$

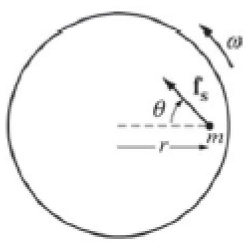
(B) $T = 2\pi\sqrt{\frac{l}{g-a}}$

(C) $T = 2\pi\sqrt{\frac{l}{g+a}}$

(D) $T = 2\pi\sqrt{\frac{l}{g}\frac{a}{(g+a)}}$

(E) $T = 2\pi\sqrt{\frac{l}{g}\frac{(g+a)}{a}}$

Problem 15:



A small particle of mass m is at rest on a horizontal circular platform that is free to rotate about a vertical axis through its center. The particle is located at a radius r from the axis, as shown in the figure above. The platform begins to rotate with constant angular acceleration α. Because of friction between the particle and the platform, the particle remains at rest with respect to the platform. When the platform has reached angular speed ω, the angle θ between the static frictional force $\mathbf{f}_s$ and the inward radial direction is given by which of the following?

(A) $\theta = \frac{\omega^2 r}{g}$

(B) $\theta = \frac{\omega^2}{\alpha}$

(C) $\theta = \frac{\alpha}{\omega^2}$

(D) $\theta = \tan^{-1}\left(\frac{\omega^2}{\alpha}\right)$

(E) $\theta = \tan^{-1}\left(\frac{\alpha}{\omega^2}\right)$