Physics Club: $F = ma$ Practice Test 2

Version 1.0

25 Questions – 75 Minutes

Assume the acceleration due to gravity near the surface of the Earth $g = 10$ m/s^2.

Correct answers will be awarded one point; incorrect answers will result in a deduction of 1/4 point. There is no penalty for leaving an answer blank.

You may use a scientific calculator. Its memory must be cleared of data and programs.

---

1. A cannon simultaneously fires two identical cannonballs at targets 1 and 2 as shown below. If the cannonballs have identical initial speeds, which one of the following statements is true? Neglect air resistance.

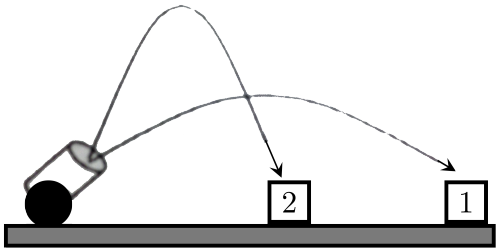
   (a) Target 1 is hit before target 2.

   (b) Target 2 is hit before target 1.

   (c) Both are hit at the same time.

   (d) Which target gets hit first cannot be determined exactly.

   (e) The kinetic energy of the cannonball that strikes target 1 must be greater than the kinetic energy of the ball that strikes target 2.



2. A large truck and a small car collide and stick together. The change in momentum of which one is larger in magnitude?

   (a) The car

   (b) The truck

   (c) The momentum change is the same for both vehicles

   (d) Cannot tell without knowing the final velocity of the combined mass

   (e) Cannot tell without knowing the masses of the truck and the car

3. A glass bottle falls off a table onto the floor and breaks into pieces. Which of the following statements regarding the process is *incorrect*?

   (a) The potential energy of the bottle has changed.

   (b) Some of the potential energy of the bottle has eventually been converted into the energy to break the bottle.

   (c) Some of the kinetic energy of the bottle has eventually been converted into the energy to break the bottle.

   (d) The impulse from the floor to the bottle is larger in magnitude than the impulse from the bottle to the floor.

   (e) The impact from the floor to the bottle breaks the bottle.

4. The kinetic energy of a particle in a simple harmonic motion is $\frac{1}{2}av^2$, its potential energy is $\frac{1}{2}bx^2$, where x is the coordinate for the position of the particle and v is its seed. Find the frequency of the motion.

   (a) $\dfrac{1}{2\pi}\sqrt{\dfrac{a}{b}}$

   (b) $\dfrac{1}{2\pi}\sqrt{\dfrac{b}{a}}$

   (c) $\dfrac{1}{2\pi}\sqrt{\dfrac{a}{b}+\dfrac{b}{a}}$

   (d) $\dfrac{1}{2\pi}\sqrt{ab}$

   (e) $\dfrac{1}{2\pi}\sqrt{\dfrac{1}{ab}}$

5. Two teams of movers are lowering a piano from the window of a 20 floor apartment building. The rope breaks when the piano is 50 meters above the ground. The movers on the ground, alerted by the shouts of the movers above, first notice the piano when it is 30 meters above the ground. How long do they have to get out of the way before the piano hits the ground?

   (a) 0.66 s

   (b) 0.78 s

   (c) 1.2 s

   (d) 1.8 s

   (e) 2.5 s

6. The diagram shows an oscillating trolley. The frequency of the oscillations can be substantially increased by

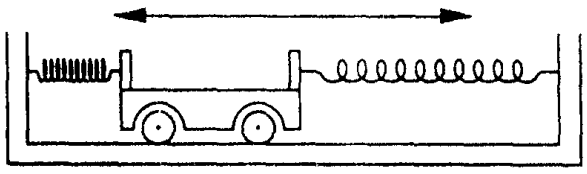
   (a) increasing the amplitude of the oscillations.

   (b) fixing an extra mass to the trolley.

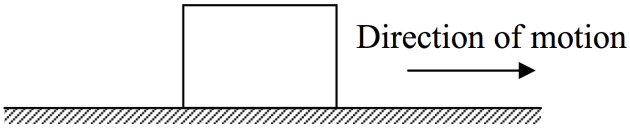
   (c) reducing the effect of friction on the trolley.

   (d) linking the trolley to the supports with a stronger pair of springs.

   (e) none of the above.

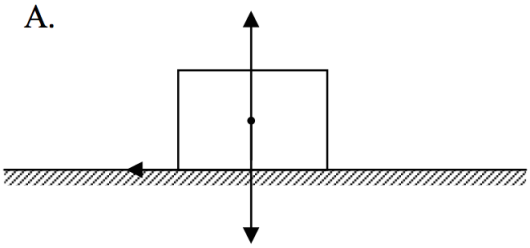


7. A block moves toward the right with a uniform deceleration along a rough horizontal surface as shown in the diagram below.

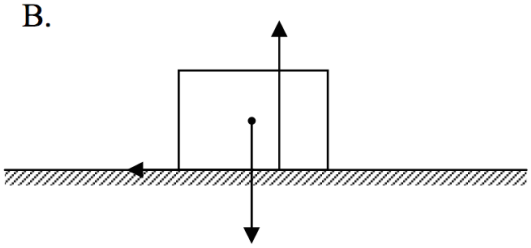


Neglecting air resistance, which one of the following diagrams correctly shows the lines of application of all the forces acting on the block? (The dot represents the block's center of mass.)

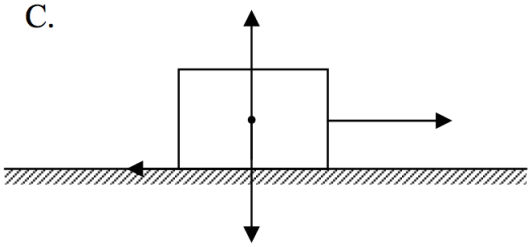
A.



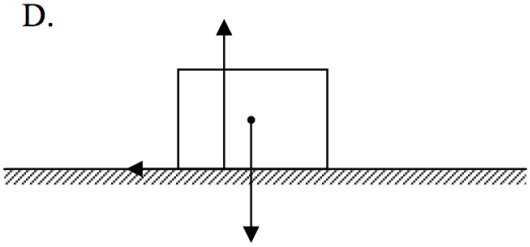
B.



C.



D.



(e) Either (c) or (d) can be correct

8. Two skaters on a frictionless icy surface push apart from one another. The first skater has a mass M which is greater than the mass m of the second skater. After some time the two skaters are at a distance d apart. How far has the lighter skater moved from her original position?

(a) $\dfrac{M}{m}d$

(b) $\dfrac{m}{M}d$

(c) d

(d) $\dfrac{m}{M+m}d$

(e) $\dfrac{M}{M+m}d$

9. An opened parachute of mass 1.0 kg is coming straight down from the sky. Attached to the parachute is the upper end of a light spring scale, while a block of mass 10 kg is attached to the lower end of the scale. The scale reading is 80 N. The air resistance at the moment is approximately

   (a) 55 N.

   (b) 66 N.

   (c) 77 N.

   (d) 88 N.

   (e) 99 N.

10. As shown in the figure, a hemispherical bowl is placed horizontally on a table. Point O is the center of the hemisphere. The edge and the surface of the bowl are smooth. A particle of mass m_1 is placed in a bowl and is tied to a string with negligible mass. The other end of the string is tied to another particle of mass m_2 hanging outside the bowl. When the system is in equilibrium, the line joining the particle m_1 and point O makes an angle $\alpha = 60°$ with the horizontal. Find the ratio m_1/m_2.

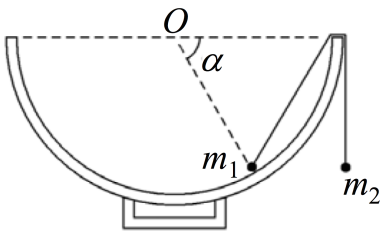
    (a) 0.71

    (b) 0.87

    (c) 1.15

    (d) 1.41

    (e) 1.73



11. As shown, one end of a light thread is fixed on the ceiling and the other end tied to a small sphere. The angle between the thread and the vertical direction is β. When $\beta = \alpha$ and α is a small angle, the sphere is in simple harmonic motion like a pendulum with period T. When $\beta = \alpha_1$ or α_2 ($\alpha < \alpha_1 < \alpha_2$), the sphere is in a uniform circular motion in a horizontal plane with period T_1 or T_2, respectively. Then the correct relation is

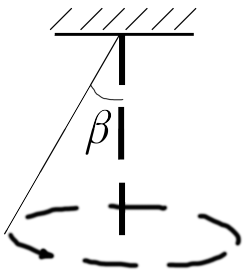
    (a) $T < T_1 < T_2$.

    (b) $T = T_1 = T_2$.

    (c) $T > T_1 > T_2$.

    (d) $T_1 < T < T_2$.

    (e) $T_1 > T > T_2$.



12. A small wooden sphere of density 0.8 g/cm^3 is attached to the end of a string of length 4.0 m in water. The other end of the string is attached to the bottom, forming a reverse pendulum. Ignore water friction. Find the period of the pendulum.

    (a) 4 s

    (b) 2 s

    (c) 5 s

    (d) 1 s

    (e) 8 s

13. A stream of water of density ρ, cross-sectional area A, and speed v strikes a wall at a height h from the ground. The wall is perpendicular to the direction of the stream, as shown in the figure below. The water then flows sideways across the wall. The force exerted by the stream on the wall is

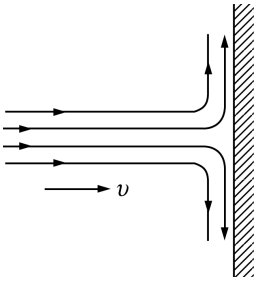
    (a) $2\rho v^2 A$.

    (b) $\rho v^2 A$.

    (c) $\rho g h A$.

    (d) $\dfrac{v^2 A}{\rho}$.

    (e) $\dfrac{v^2 A}{2\rho}$.



14. A block of mass M_1 is hung by a light spring of force constant k to the top bar of a reverse U-frame of mass M_2 on the floor. The block is pooled down from its equilibrium position by a distance x and then released. Find the minimum value of x such that the reverse U-frame will leave the floor momentarily.

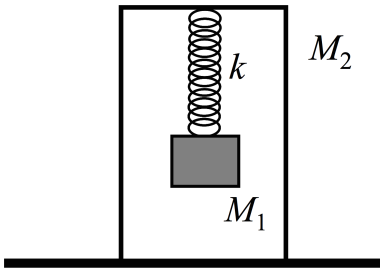
    (a) $(M_1 + M_2)\,\dfrac{g}{k}$

    (b) $(2M_1 + M_2)\,\dfrac{g}{k}$

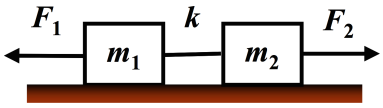
    (c) $(M_1 + 2M_2)\,\dfrac{g}{k}$

    (d) $M_1 \dfrac{g}{k}$

    (e) $M_2 \dfrac{g}{k}$



15. As shown in the figure, two blocks of masses m_1 and m_2 are connected by a light string, and are placed on a horizontal smooth surface. Forces of magnitude F_1 and F_2 act on them respectively, causing them to move linearly. The force constant of the light string is k, and $F_1 > F_2$. What is the extension x of the light string?



(a) $\dfrac{F_1 m_1 + F_2 m_2}{k(m_1 + m_2)}$

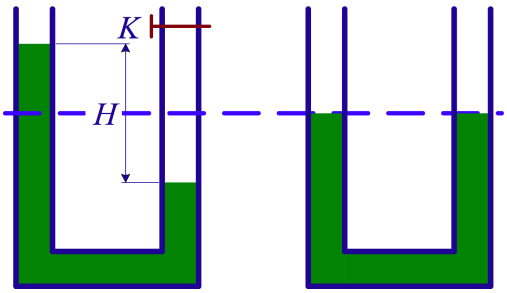
(b) $\dfrac{F_1 m_2 + F_2 m_1}{k(m_1 + m_2)}$

(c) $\dfrac{|F_1 m_2 - F_2 m_1|}{k(m_1 + m_2)}$

(d) $\dfrac{|F_1 m_1 - F_2 m_2|}{k(m_1 + m_2)}$

(e) $\dfrac{F_1 m_1 + F_2 m_2}{k|m_1 - m_2|}$

16. A U-tube of small and uniform cross section contains water of total length $4H$. The height difference between the water columns on the left and on the right is H when the valve K is closed. The valve is suddenly open, and water is flowing from left to right. Ignore friction. Find the speed of water when the heights of the left and the right water columns are the same.



(a) $\dfrac{1}{4}\sqrt{gH}$

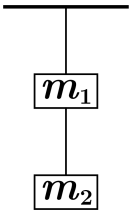
(b) $\sqrt{\dfrac{gH}{8}}$

(c) $\dfrac{1}{2}\sqrt{gH}$

(d) $\sqrt{\dfrac{gH}{2}}$

(e) $\sqrt{gH}$

17. Two blocks of mass $m_1 = 2$ kg and $m_2 = 4$ kg are suspended by two light strings to the ceiling as shown in the accompanying figure. If the upper string is suddenly broken, the accelerations of m_1 and m_2 at the moment when the upper string is broken are, respectively,



(a) $a_1 = 10$ m/s^2 and $a_2 = 0$ m/s^2.

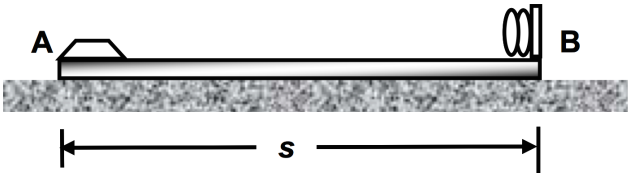
(b) $a_1 = 10$ m/s^2 and $a_2 = 10$ m/s^2.

(c) $a_1 = 20$ m/s^2 and $a_2 = 0$ m/s^2.

(d) $a_1 = 20$ m/s^2 and $a_2 = 10$ m/s^2.

(e) $a_1 = 30$ m/s^2 and $a_2 = 0$ m/s^2.

18. As shown in the figure, AB is a board of mass $M = 4$ kg and length $s = 2$ m, placed on a smooth horizontal surface. A bumper of negligible mass is fixed at end B. A peg of mass $m = 1$ kg is placed at end A. The coefficient of kinetic friction between the peg and the board is $\mu = 0.2$. With the board initially at rest, the peg is ejected with an initial velocity of $v_0 = 10$ m/s along the board surface. The peg is in contact with the board until it hits the bumper at end B. After the collision, the peg is just able to return to end A without falling off the board, Find the mechanical energy lost in the process.



(a) 20 J

(b) 24 J

(c) 28 J

(d) 32 J

(e) 40 J

19. Object A is dropped from a height h. At the same instant object B is thrown vertically upward from the ground. Right before they collide in mid-air, the speed of A is three times the speed of B. Which of the following can be the height where the collision occurs?

(a) $\dfrac{2h}{3}$

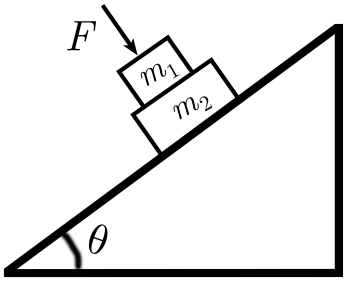
(b) $\dfrac{h}{\sqrt{3}}$

(c) $\dfrac{3h}{4}$

(d) $\dfrac{h}{2}$

(e) $\dfrac{h}{4}$

20. A force F is used to hold two blocks of mass m_1 and m_2 on an incline as shown in the diagram. The plane makes an angle θ with the horizontal and F is perpendicular to the plane. The coefficients of static friction between the plane and the block m_2 and between the two blocks are both equal to μ with $\mu < \tan\theta$. What is the minimum force F necessary to keep both blocks at rest?



(a) $\mu\,(m_1 + m_2)$

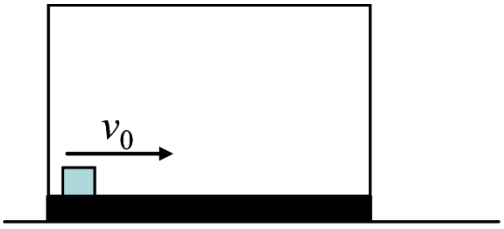
(b) $(m_1 + m_2)\,g\cos\theta$

(c) $m_1 g\left(\dfrac{\sin\theta}{\mu} - \cos\theta\right)$

(d) $m_2 g\left(\dfrac{\sin\theta}{\mu} - \cos\theta\right)$

(e) $(m_1 + m_2)\,g\left(\dfrac{\sin\theta}{\mu} - \cos\theta\right)$

21. As shown, a big box of mass M is resting on a horizontal smooth floor. On the bottom of the box there is a small box also of mass M. The block is given an initial peed v_0 relative to the floor, and starts to bounce back and forth between the two walls of the box. Find the final speed of the box when the block has finally come to rest in the box.



(a) 0

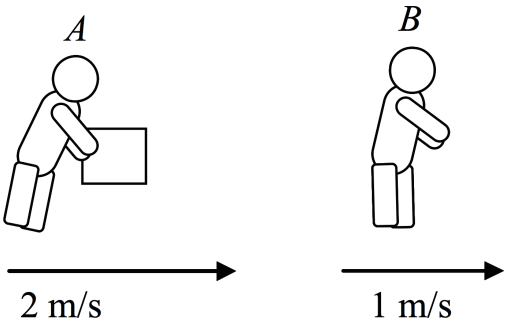
(b) v_0

(c) $v_0/2$

(d) $v_0/3$

(e) $v_0/4$

22. Two astronauts, A and B, both with mass of 60 kg, are moving along a straight line in the same direction in a "weightless" spaceship. Relative to the spaceship the speed of A is 2 m/s and that of B is 1 m/s. A is carrying a bag of mass 8 kg with him. To avoid collision with B, A throws the bag with a speed v relative to the spaceship toward B and B catches it. Find the minimum value of v.



(a) 7.8 m/s

(b) 26.0 m/s

(c) 14.0 m/s

(d) 9.2 m/s

(e) 5.5 m/s

23. As shown in the diagram, a man pushes forward on the compartment which is accelerating uniformly to the left relative to the ground. The man stays at rest relative to the compartment. Which of the following statements in respect to the ground reference frame is correct?

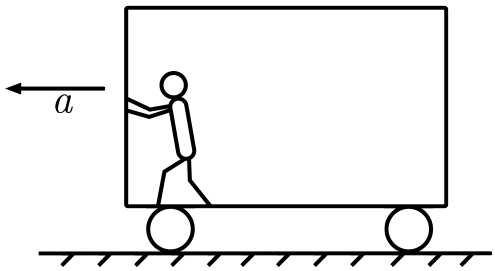
(a) The man does positive work on the compartment.

(b) The man does negative work on the compartment.

(c) The man does zero work on the compartment.

(d) It cannot be determined

(e) Both (a) and (c) can be correct.



24. As shown in the figure, AB = 3.5 m, AC = 3.0 m, AD = 0.5 m. The two rods AC and BC weight 200 N each. The floor is frictionless. Find the tension in the rope.

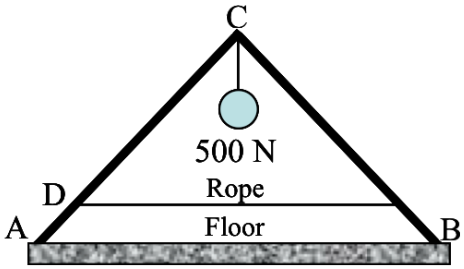
(a) 280 N

(b) 500 N

(c) 150 N

(d) 302 N

(e) 180 N



25. A small weight of mass $2M$ is attached to the bottom of a hollow sphere of mass M and radius R. Half of the sphere is submerged when floating in water. Find the period T of the simple harmonic oscillation of the sphere in the vertical direction.

(a) $2\pi\sqrt{\dfrac{R}{2g}}$

(b) $2\pi\sqrt{\dfrac{3R}{2g}}$

(c) $2\pi\sqrt{\dfrac{R}{g}}$

(d) $2\pi\sqrt{\dfrac{2R}{3g}}$

(e) $2\pi\sqrt{\dfrac{R}{3g}}$