Physics Club: $F = ma$ Practice Test 1

Version 1.1

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.

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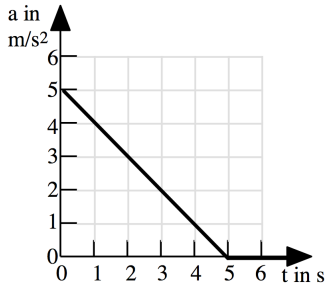
1. Starting from rest at time $t = 0$, a car moves in a straight line with an acceleration given by the accompanying graph. What is the speed of the car at $t = 2$ s?



   (a) 1.0 m/s

   (b) 2.0 m/s

   (c) 8.0 m/s

   (d) 10.5 m/s

   (e) 12.5 m/s

The following information is used for questions 2 and 3.
A flare is dropped from a plane flying over level ground at a velocity of 70 m/s in the horizontal direction. At the instant the flare is released, the plane begins to accelerate horizontally at 1.75 m/s^2. The flare takes 4.5 s to reach the ground.

2. Relative to a spot directly under the flare at release, the flare lands

   (a) directly on the spot.

   (b) 333 m in front of the spot.

   (c) 274 m in front of the spot.

   (d) 280 m in front of the spot.

   (e) 315 m in front of the spot.

3. As seen by the pilot of the plane and measured relative to a spot directly under the plane when the flare lands, the flare lands

   (a) 333 m behind the plane.

   (b) 18 m behind the plane.

   (c) directly under the plane.

   (d) 36 m in front of the plane.

   (e) 315 m in front of the plane.

4. A certain football quarterback can throw a football a maximum range of 76 meters on level ground. What is the highest point reached by the football when this maximum range is thrown?

   (a) 76 m

   (b) 54 m

   (c) 38 m

   (d) 28 m

   (e) 19 m

5. A car of mass m is slipping down a slope of inclination angle θ at a constant acceleration a. The coefficient of static friction between the wheels and the slope is μ. What is the frictional force between the wheels and the slope?

   (a) $\mu mg \cos\theta$

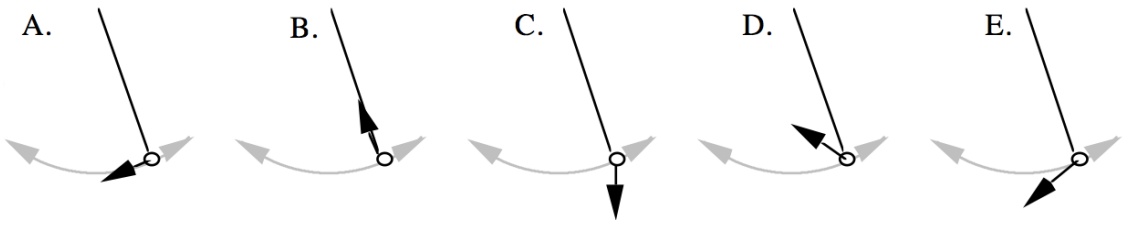
   (b) μmg

   (c) $mg\,(\sin\theta - \mu)$

   (d) $m\,(g - a)$

   (e) $mg \sin\theta - ma$

6. Which solid vector in the accompanying figures best represents the acceleration of the pendulum mass at the intermediate point in its swing indicated?



7. A ball of mass m is fastened to a string. The ball swings in a vertical circle of radius R with the other end of the string held fixed. The difference between the string's tension at the bottom of the circle and at the top is

   (a) $8mg$.

   (b) $6mg$.

   (c) $4mg$.

   (d) $2mg$.

   (e) mg.

8. Two objects of mass m and $3m$ are placed at either end of a spring of spring constant k and the whole system is placed on a horizontal frictionless surface. At what angular frequency ω does the system oscillate?

   (a) $\sqrt{\dfrac{k}{m}}$

   (b) $\sqrt{\dfrac{3k}{m}}$

   (c) $\sqrt{\dfrac{3k}{2m}}$

   (d) $\sqrt{\dfrac{2k}{3m}}$

   (e) $\sqrt{\dfrac{4k}{3m}}$

9. Two uniform circular disks of the same material and thickness are adhered together at point N. Both disks lie in the same vertical plane. The rigid body is hinged at point P and it can rotate freely about P in the vertical plane. PO $\perp$ OM and ON = 3 NM, where point O and point M are the centers of the disks. When static equilibrium is reached, find the angle θ between PO and the vertical direction.

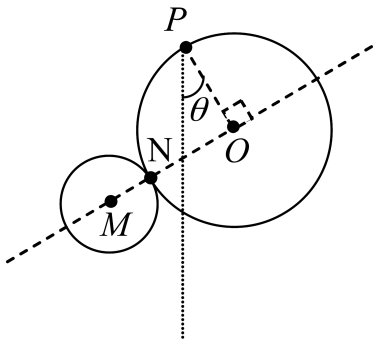
   (a) 16.7°

   (b) 26.6°

   (c) 30°

   (d) 5.2°

   (e) 7.6°



10. A uniform 2 kg cylinder rests on a laboratory trolley as shown. The coefficient of static friction between the cylinder and the trolley is 0.5. If the cylinder is 4 cm in diameter and 10 cm in height, what is the condition on the acceleration a of the trolley to cause the cylinder to tip over?

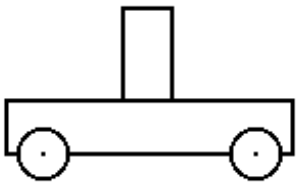
    (a) $a > 2.5$ m/s^2

    (b) $a < 2.5$ m/s^2

    (c) $a > 5$ m/s^2

    (d) $a > 4$ m/s^2

    (e) The cylinder would tip over at any acceleration.



11. Four masses M are arranged at the vertices of a square of side length a. What is the gravitational potential energy of this arrangement?

(a) $-\left(4+\sqrt{2}\right)\dfrac{GM^2}{a}$

(b) $-\left(4-\sqrt{2}\right)\dfrac{GM^2}{a}$

(c) $-4\dfrac{GM^2}{a}$

(d) $-\left(2+\sqrt{2}\right)\dfrac{GM^2}{a}$

(e) $-\left(2-\sqrt{2}\right)\dfrac{GM^2}{a}$

12. A particle of mass m moving along the x-axis with speed v collides with a particles of mass $2m$ initially at rest. After the collision, the first particle has come to rest, and the second particle has split into two equal-mass pieces that move at equal angle θ with the x-axis, as shown in the figure. Which of the following statements correctly describes the speeds of the two pieces?

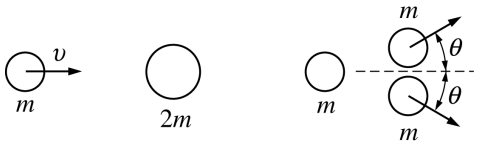
(a) Both pieces move with speed v.

(b) One of the pieces moves with speed v, the other moves with speed less than v.

(c) Both pieces move with speed $v/2$.

(d) One of the pieces moves with speed $v/2$, the other moves with speed greater than $v/2$.

(e) Both pieces move with speed greater than $v/2$.



13. A spacecraft is orbiting on the surface of an unknown planet. In order to determine the density of the planet, which one of the following should be measured?

(a) Radius of the planet

(b) The volume of the planet

(c) The moving speed of the spacecraft

(d) The period of the motion

(e) None of the above measurements would determine the density of the planet.

The following information is used for questions 14 and 15.
Two weights, both of mass m, are joined by a weightless spring of natural length L and force constant k. They are placed on a smooth surface and at rest. One weight is given an impulse and acquires an initial velocity v toward the other weight.

14. What is the speed of the center of mass of the weights-spring system?

    (a) $0.5v$

    (b) $0.5v - \sqrt{\dfrac{kL^2}{2m}}$

    (c) $\sqrt{\dfrac{kL^2}{2m}} - 0.5v$

    (d) v

    (e) $0.5v - \sqrt{\frac{kL^2}{m}}$

15. What is the minimum distance between the two weights?

    (a) $L - \dfrac{v}{2}\sqrt{\dfrac{m}{k}}$

    (b) $L - v\sqrt{\dfrac{m}{2k}}$

    (c) $L - v\sqrt{\dfrac{m}{k}}$

    (d) $v\sqrt{\dfrac{m}{k}}$

    (e) $\dfrac{v}{2}\sqrt{\dfrac{m}{k}}$

16. A rod of mass M and length L mass moment of inertia $(1/12)\,ML^2$ about its center of mass. A sphere of mass m and radius R has a moment of inertia $(2/5)\,mR^2$ about its center of mass. A combined system is formed by centering the sphere at one end of the rod and placing an axis at the other. What is the moment of inertia I of the combined system about the axis shown?

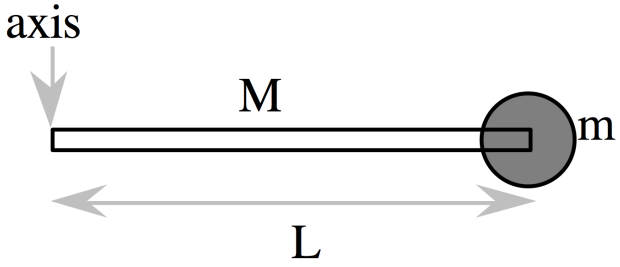
    (a) $\dfrac{1}{12}ML^2 + \dfrac{2}{5}mR^2$

    (b) $\dfrac{1}{12}ML^2 + \dfrac{2}{5}mR^2 + ML^2$

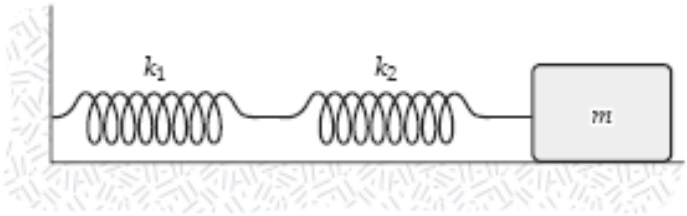
    (c) $\dfrac{1}{3}ML^2 + \dfrac{2}{5}mR^2 + mL^2$

    (d) $\dfrac{1}{12}ML^2 + mL^2$

    (e) $\dfrac{1}{3}ML^2 + mL^2$



17. The mass in the figure below slides on a frictionless surface. When the mass is pulled out, spring 1 is stretched to a distance x_1 from its equilibrium position and spring 2 is stretched a distance x_2. The spring constants are k_1 and k_2, respectively. Find the force pulling back on the mass.



(a) $-k_2 x_1$

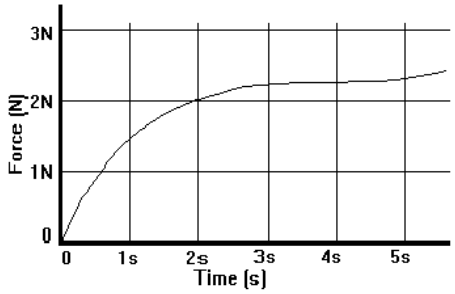
(b) $-k_1 x_2$

(c) $-(k_1 x_1 + k_2 x_2)$

(d) $-\dfrac{k_1 + k_2}{2}(x_1 + x_2)$

(e) $-\dfrac{k_1 k_2}{k_1 + k_2}(x_1 + x_2)$

18. An object with a mass of 3 kilograms is accelerated from rest. The graph at right shows the magnitude of the net force in newtons as a function of time in seconds. At time $t = 4$ seconds the object's velocity would have been closest to which of the following?



(a) 2.3 m/s

(b) 3.5 m/s

(c) 5.8 m/s

(d) 7.0 m/s

(e) 11.5 m/s

19. Three small objects, all of mass M, are released simultaneously from the top of three inclined planes of the same height H. The objects and incline angles of the corresponding incline planes are described as follows:

I. a cube of side R from an incline plane with an incline angle of 30°

II. a solid cylinder of radius R from an incline plane with an incline angle of 45°

III. a hollow cylinder of radius R from an incline plane with an incline angle of 60°

Assume that the cylinders roll down their corresponding incline planes without slipping and the cube slides down the plane without friction. Which objects reach the bottom of the plane first?

(a) I

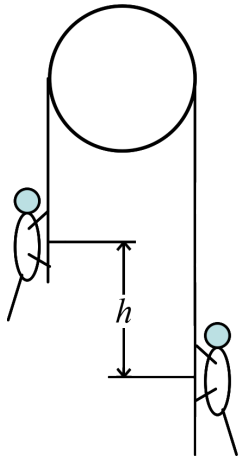
(b) II

(c) III

(d) I & II

(e) II & III

20. Two monkeys of the same weight are holding tightly the two end of a rope with negligible mass. The rope passes through a smooth pulley, as shown in the figure. The two monkeys are initially at rest. Now the right monkey starts to climb up the rope at an average speed v relative to the pulley to get closer to the left monkey. Let the initially vertical separation of the monkeys be h. Find the average velocity of the right monkey relative to the left monkey.



(a) $2v$ upward

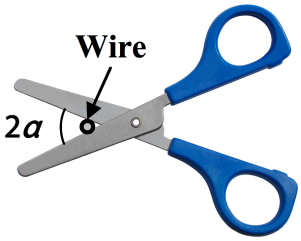
(b) $2v$ downward

(c) $v + \sqrt{2gh}$ upward

(d) $v + \sqrt{2gh}$ downward

(e) 0

21. Someone is using scissors to cut a wire of circular cross section and negligible weight. The wire slides in the direction away from the hinge until the angle between the scissors blades becomes 2α. The coefficient of kinetic friction between the blades and the wire is closest to



(a) $\sqrt{1 - \tan\alpha}$.

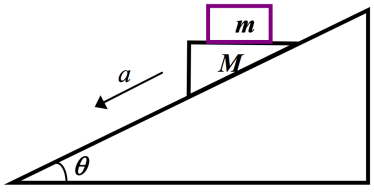
(b) $\cos 2\alpha$.

(c) $\tan 2\alpha$.

(d) $\tan\alpha$.

(e) $\sqrt{2\cos^2\alpha - 1}$.

22. As shown in the figure, a wedge of mass M is placed on a smooth inclined ramp that makes an angle θ with the horizontal. An object of mass m rests on top of the wedge. The system is sliding down the ramp at acceleration a. Determine the apparent weight of the object m as it slides down. Note that there is friction between the object and the wedge so that the object remains relatively at rest on the wedge.



(a) $mg\cos\theta$

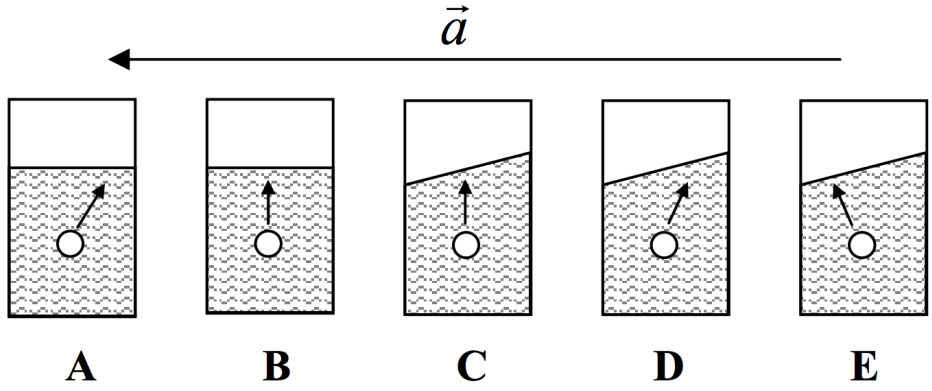
(b) $mg\cos^2\theta$

(c) $mg\sin\theta\cos\theta$

(d) $mg\tan\theta$

(e) mg

23. A cup of water is placed in a car under constant acceleration to the left, as shown. Inside the water is a small air bubble. The following figures show five situations of the shape of the water surface and the direction of motion of the bubble as indicated by the arrow on the bubble. Which one is correct?



24. A uniform sphere of mass m and radius R has moment of inertia $(2/5)\,mR^2$ about its center of mass. A uniform spherical ball is observed to roll without slipping down a plane inclined at an angle θ with the horizontal. It follows that the coefficient of static friction between the ball and the plane μ_s must satisfy the relation:

(a) $\mu_s \geq \frac{2}{7}\tan\theta$

(b) $\mu_s = \frac{2}{7}\tan\theta$

(c) $\mu_s \leq \frac{2}{7}\tan\theta$

(d) $\mu_s \geq \frac{5}{7}\tan\theta$

(e) $\mu_S \leq \frac{5}{7}\tan\theta$

25. A ball is released vertically from a height H above an incline and makes several bounces. The angle of the incline is θ. Assume the ball bounces elastically in each hit. Calculate the distance along the incline from the first hit to the fifth hit.

(a) $4H\cos\theta$

(b) $24H\cos\theta$

(c) $48H\sin\theta$

(d) $64H\sin\theta$

(e) $80H\sin\theta$