Chapter 7 Drill

The answers and explanations can be found in Chapter 17.

Section I: Multiple Choice

1. A force **F** of strength 20 N acts on an object of mass 3 kg as it moves a distance of 4 m. If **F** is perpendicular to the 4 m displacement, the work it does is equal to

(A) 0 J
(B) 60 J
(C) 80 J
(D) 600 J
(E) 2,400 J

2. Under the influence of a force, an object of mass 4 kg accelerates from 3 m/s to 6 m/s in 8 s. How much work was done on the object during this time?

(A) 27 J
(B) 54 J
(C) 72 J
(D) 96 J
(E) Cannot be determined from the information given

3. A student is asked to lift a box of mass m up to a height h. The student has the options of simply lifting the box, pushing it up an inclined plane of angle 30 , or using a pulley system in which the rope is looped around the pulley 4 times. If these are labeled as Option 1, Option 2, and Option 3 respectively, which of the following correctly shows the relationship of the work needed to lift the block in each situation? Assume ideal conditions.

(A) Option 1 > Option 2 > Option 3
(B) Option 1 > Option 2 = Option 3
(C) Option 1 = Option 3 > Option 2
(D) Option 1 = Option 2 = Option 3
(E) Cannot be determined without additional information

4. A 4 kg box is pulled up a ramp of angle $\theta = 30$ degrees and height = 5 m at a constant velocity. How much work is done by the normal force?

(A) 160 J
(B) 80 J
(C) 40 J
(D) 20 J
(E) 0 J

5. A man stands in an elevator as it begins to ascend. Does the normal force from the floor do work on the man?

(A) Yes, and the work done will be positive.
(B) Yes, and the work done will be negative.
(C) Yes, but the sign can't be determined.
(D) No, the normal force will do no work in any situation.
(E) No, the normal force will do no work in this situation, but it can in others.

6. A block of mass 3.5 kg slides down a frictionless inclined plane of length 6.4 m that makes an angle of 30° with the horizontal. If the block is released from rest at the top of the incline, what is its speed at the bottom?

(A) 5.0 m/s
(B) 5.7 m/s
(C) 6.4 m/s
(D) 8.0 m/s
(E) 10 m/s

7. A block of mass m slides from rest down an inclined plane of length s and height h. If F is the magnitude of the force of kinetic friction acting on the block as it slides, then the kinetic energy of the block when it reaches the bottom of the incline will be equal to

(A) mgh
(B) $mgh - Fh$
(C) $mgs - Fh$
(D) $mgh - Fs$
(E) $mgs - Fs$

8. If a 1,000 kg car is accelerating at a rate of 4 m/s^2 and experiencing 300 N of drag force, how much force do the engines have to produce? Ignore any frictional effects with the road.

(A) 16,300 N
(B) 15,700 N
(C) 4,300 N
(D) 4,000 N
(E) 3,700 N

9. An astronaut drops a rock from the top of a crater on the Moon. When the rock is halfway down to the bottom of the crater, its speed is what fraction of its final impact speed?

   (A) $\frac{1}{4\sqrt{2}}$

   (B) $\frac{1}{4}$

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

   (D) $\frac{1}{2}$

   (E) $\frac{1}{\sqrt{2}}$

10. A block of mass m is at rest at the bottom of an inclined ramp of length d and angle θ. A string is attached to the block and connected to a motor that pulls on the string. The coefficient of friction between the block and the ramp as it slides up is μ. What is the minimum constant power P that the motor can expend to make the block reach the top of the ramp in t seconds?

    (A) $m\left(\frac{d^2}{t^3} + \frac{gd\sin\theta}{t} + \frac{dg\mu\cos\theta}{t}\right)$

    (B) $m\left(\frac{d^2}{t} + \frac{gd\sin\theta}{t} + \frac{dg\mu\cos\theta}{t}\right)$

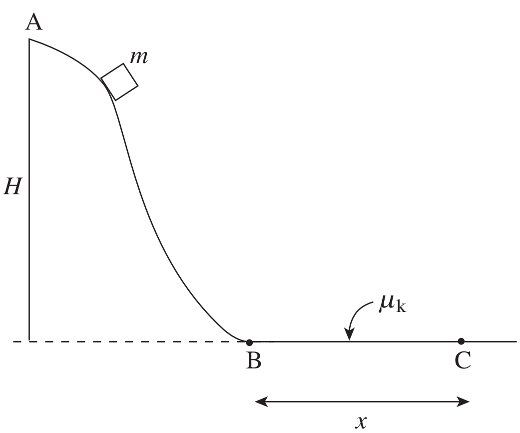
    (C) $m\left(\frac{d^2}{t} + \frac{gd\cos\theta}{t} \quad \frac{dg\mu\sin\theta}{t}\right)$

    (D) $m\left(\frac{2d^2}{t^3} + \frac{gd\sin\theta}{t} + \frac{dg\mu\cos\theta}{t}\right)$

    (E) $m\left(\frac{2d^2}{t^3} + \frac{gd\cos\theta}{t} + \frac{dg\mu\sin\theta}{t}\right)$

Section II: Free Response

1. A box of mass m is released from rest at point A, the top of a long, frictionless slide. Point A is at height H above the level of points B and C. Although the slide is frictionless, the horizontal surface from point B to C is not. The coefficient of kinetic friction between the box and this surface is μ_k, and the horizontal distance between point B and C is x.



Solve for the following in terms of given quantities and the acceleration of gravity, g.

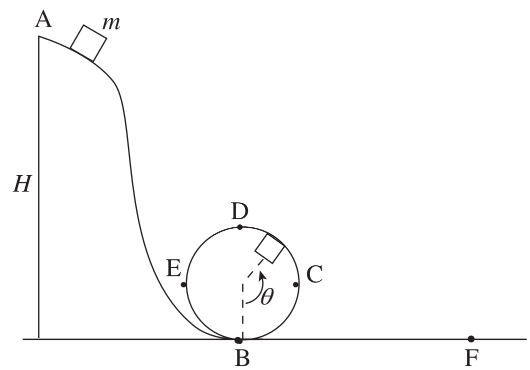
(a) Find the speed of the box when its height above point B is $\frac{1}{2}H$.

(b) Find the speed of the box when it reaches point B.

(c) Determine the value of μ_k so that the box comes to rest at point C.

(d) Now assume that points B and C were not on the same horizontal level. In particular, assume that the surface from B to C had a uniform upward slope so that point C was still at a horizontal distance of x from B but now at a vertical height of y above B. Answer the question posed in part (c).

2. The diagram below shows a roller-coaster ride which contains a circular loop of radius r. A car (mass m) begins at rest from point A and moves down the frictionless track from A to B where it then enters the vertical loop (also frictionless), traveling once around the circle from B to C to D to E and back to B, after which it travels along the flat portion of the track from B to F (which is not frictionless).



Solve for the following in terms of given quantities and the acceleration of gravity, g.

(a) Find the centripetal acceleration of the car when it is at point C.

(b) What is the minimum cut-off speed v_c that the car must have at point D to make it around the loop?

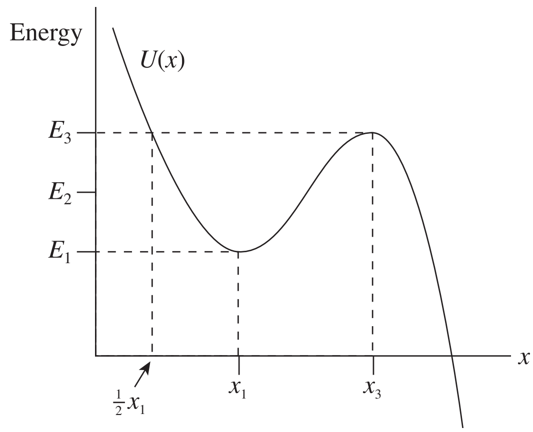
(c) What is the minimum height H necessary to ensure that the car makes it around the loop?

(d) If $H = 6r$ and the coefficient of friction between the car and the flat portion of the track from B to F is 0.5, how far along this flat portion of the track will the car travel before coming to rest at point F?

3. A ball $m = 3$ kg has the potential energy function

   $U(x) = 3(x - 1) - (x - 3)^3$

   where x is measured in meters and U in joules. The following graph is a sketch of this potential energy function.



   The energies indicated on the vertical axis are evenly spaced; that is, $E_3 - E_2 = E_2 - E_1$. The energy E_1 is equal to $U(x_1)$, and the energy E_3 is equal to $U(x_3)$.

   (a) Determine the numerical values of x_1 and x_3.

   (b) Describe the motion of the particle if its total energy is E_2.

   (c) What is the particle's speed at $x = x_1$ if its total energy, E, equals 58 J?

   (d) Sketch the graph of the particle's acceleration as a function of x. Be sure to indicate x_1 and x_3 on your graph.

   (e) The particle is released from rest at $x = \frac{1}{2}x_1$. Find its speed as it passes through $x = x_1$.

4. The force on a 6 kg object is given by the equation: $F(x) = 3x + 5$, in newtons. The object is moving 2 m/s at the origin.

   (a) Determine the work done on the object by the force when it is moved 4 m from the origin in the x direction.

   (b) Determine the speed of the object when it has moved 4 m.