

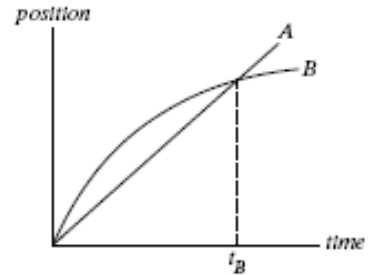


Student ID _____

STUDENT'S NAME: _____

PART I Multiple choice. (48% of the test grade). Enter all your answers in the scantron sheet.

1 The graph shows position as a function of time for two trains running on parallel tracks. Which is true:



- a. At time t_B , both trains have the same velocity.
- b Both trains speed up all the time.
- c. Both trains have the same velocity at some time before t_B .
- d. Somewhere on the graph, both trains have the same acceleration.
- e. Other

2 A group of students needs to cross a river in the shortest time. The water in the river flows downstream at a speed of 10m/s. The boat has a maximum speed of 20m/s In what direction should the students head the boat?

- a. Downstream
- b. Directly toward the opposite shore
- c. 30° away from upstream
- d. 60° away from upstream
- e. Upstream

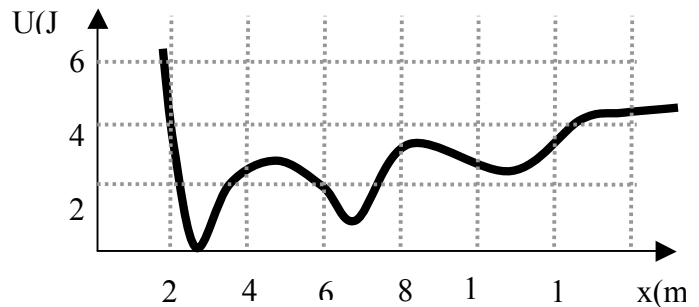
3. A 2.0 kg mass starts from rest and is acted on by a constant net force. If the mass moves 64 m in 4.0 s, what is the force in N?

- a. 4
- b. 8
- c. 16
- d. 32
- e. 64

4 A bucket tied at the end of a 8.27 m long string is whirled in a vertical circle with a constant speed. What should be the minimum speed of the bucket, so that the water from the bucket does not spill when the bucket is (upside down) at the highest position?

- a. 7
- b. 8
- c. 9
- d. 10
- e. none of the above

5 At $t=0$ particle is at rest $x=2m$ After its release it can move under influence of conservative force whose potential energy is shown in the diagram. What is the kinetic energy of this particle when its position $x=6m$?



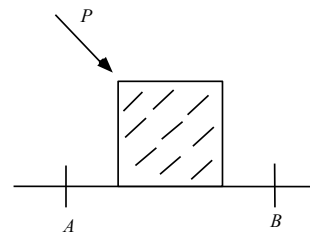
- a 0 J
- b 1 J
- c 2 J
- d 4 J
- e none of the above

6 A train slows down as it rounds a sharp horizontal turn, slowing at constant rate from 30.0 m/s to 15. m/s in the 15.0 s that it takes to round the bend. The radius of the curvature of the bend is 200 m.

Compute the magnitude of acceleration (in m/s^2) at the moment the train speed reaches 20.0 m/s.

- a. 0
- b. 1.45
- c. 2.23
- d. 3.15
- e. none of the above

7. A block is pushed across a rough horizontal surface from point A to point B by a force (magnitude $P = 5.4$ N) as shown in the figure. The magnitude of the force of friction acting on the block between A and B is 1.2 N and points A and B are 0.5 m apart. If the kinetic energies of the block at A and B are 4.0 J and 5.6 J, respectively, how much work in J is done on the block by the force P between A and B?



- a. 2.2
- b. 2.7
- c. 1.6
- d. 3.2
- e. 1.0

Part II

In the exam booklet provide full solutions to 5 out of 6 problems .

Each problem is worth 10 points.

On the cover of your exam booklet indicate clearly which problems are to be marked.

Provide full solutions with clear diagrams. Clarity of your solution is important!

1. A motorist drives along a straight road at a constant speed of 15.0 m/s. Just as she passes a parked motorcycle police officer, the officer starts to accelerate at 2.00 m/s^2 to overtake her. Assuming that the officer maintains this acceleration,

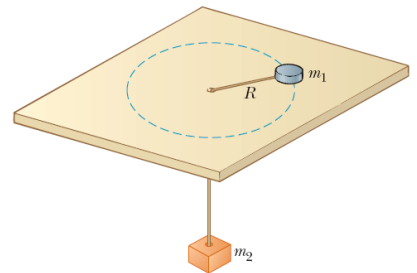
- determine the time interval required for the police officer to reach the motorist. (4p)
- find the speed of the officer as he overtakes the motorist (4p)
- the total displacement of the officer as he overtakes the motorist. (2p)

2. A ball is tossed from an upper-story window of a building. The ball is given an initial velocity of 8.00 m/s at an angle of 20.0° below the horizontal. It strikes the ground 3.00 s later.

- How far horizontally from the base of the building does the ball strike the ground? (4p)
- Find the height from which the ball was thrown. (4p)
- What is the kinetic energy of the ball when it hits the ground (2p)

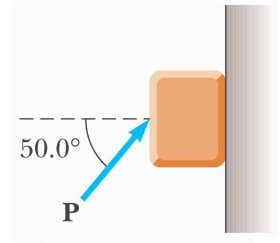
3. An air puck of mass $m_1 = 0.100 \text{ kg}$ is tied to a string and allowed to revolve in a circle of radius $R = 0.5 \text{ m}$ on a frictionless horizontal table. The other end of the string passes through a hole in the center of the table, and a counterweight of mass $m_2 = 0.200 \text{ kg}$ is tied to it. The suspended object remains in equilibrium while the puck on the tabletop revolves.

- draw free body diagram for the puck and the hanging mass (2p)
- write Newton's Equations in component form for both objects (3p)
- find the tension in the string, (2p)
- find the radial force acting on the puck, (2p)
- find the speed of the puck? (1p)

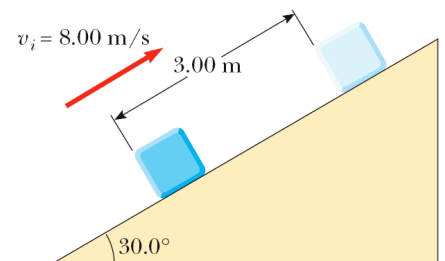


4. A block of mass 2.00 kg is pushed up against a wall

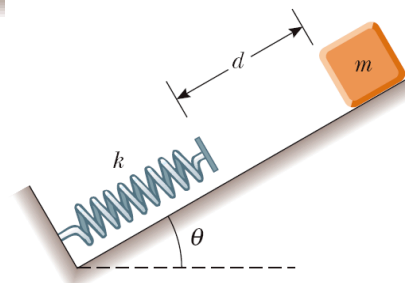
by a force P that makes a 50.0° angle with the horizontal as shown in Figure. The coefficient of static friction between the block and the wall is 0.250. Determine the minimum value for the magnitude of P that allow the block to remain stationary.



4. A 5.00-kg block is set into motion up an inclined plane with an initial speed of 8.00 m/s (Fig. P7.25). The block comes to rest after traveling 3.00 m along the plane, which is inclined at an angle of 30.0° to the horizontal. For this motion, determine (a) the change in the block's kinetic energy, (b) the change in the potential energy of the block-Earth system, and (c) the friction force exerted on the block (assumed to be constant). (d) What is the coefficient of kinetic friction?



5. An object of mass $m = 1 \text{ kg}$ starts from rest and slides a distance d down a frictionless incline of angle $\theta = 15 \text{ degrees}$. While sliding, it contacts an unstressed spring of negligible mass as shown in. The object slides an additional distance $x = 2 \text{ cm}$ as it is brought momentarily to rest by compression of the spring (of force constant $k = 1000 \text{ N/m}$). Find the initial separation d between the object and the spring.



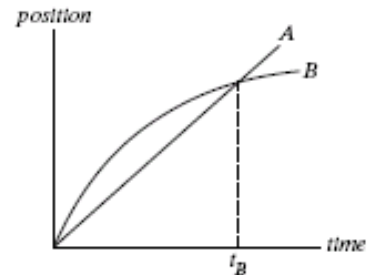


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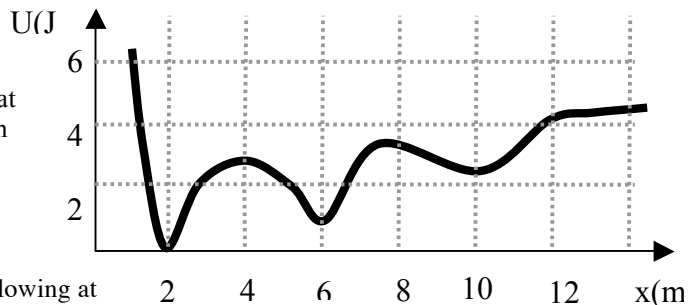


- 2 A group of students needs to cross a river in such a way that they travel the shortest distance in water. The water in the river flows downstream at a speed of 10m/s. The boat has a maximum speed of 20m/s. In what direction should the students head the boat?
 a. Downstream
 b. Directly toward the opposite shore
 c. 30° away from upstream
 d. 60° away from upstream
 e. Upstream

3. A 2.0 kg mass starts from rest and is acted on by a constant net force. If the mass moves 32 m in 4.0 s, what is the force in N?
 a. 4
 b. 8
 c. 16
 d. 32
 e. 64

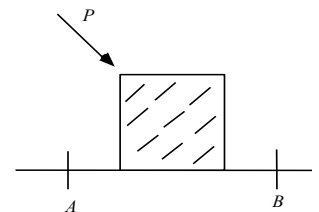
- 4 A bucket tied at the end of a 10.20 m long string is whirled in a vertical circle with a constant speed. What should be the minimum speed of the bucket, so that the water from the bucket does not spill when the bucket is (upside down) at the highest position?
 a. 7
 b. 8
 c. 9
 d. 10
 e. none of the above

- 5 At $t=0$ particle is at rest $x=12\text{m}$. After its release it can move under influence of conservative force whose potential energy is shown in the diagram. What is the kinetic energy of this particle when its position $x=2\text{m}$?
 a 0 J
 b 1 J
 c 2 J
 d 4 J
 e none of the above



- 6 A train slows down as it rounds a sharp horizontal turn, slowing at constant rate from 30.0 m/s to 15. m/s in the 15.0 s that it takes to round the bend. The radius of the curvature of the bend is 200 m. Compute the magnitude of acceleration (in m/s^2) at the moment the train speed reaches 15.0 m/s.
 a. 0
 b. 1.51
 c. 2.23
 d. 3.15
 e. none of the above

7. A block is pushed across a rough horizontal surface from point A to point B by a force (magnitude $P = 5.4\text{ N}$) as shown in the figure. The magnitude of the force of friction acting on the block between A and B is 1.2 N and points A and B are 1.0m apart. If the kinetic energies of the block at A and B are 4.0 J and 5.6 J, respectively, how much work in J is done on the block by the force P between A and B?



- a. 2.2
 b. 2.0
 c. 1.6
 d. 3.2
 e. 2.8

Part II

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Provide full solutions with clear diagrams. Clarity of your solution is important!

1. A motorist drives along a straight road at a constant speed of 15.0 m/s. Just as she passes a parked motorcycle police officer, the officer starts to accelerate at 1.50 m/s^2 to overtake her. Assuming that the officer maintains this acceleration,

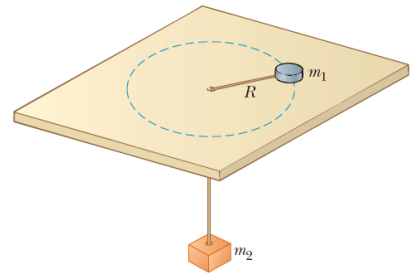
- determine the time interval required for the police officer to reach the motorist. (4p)
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- the total displacement of the officer as he overtakes the motorist. (2p)

2. A ball is tossed from an upper-story window of a building. The ball is given an initial velocity of 7.00 m/s at an angle of 20.0° below the horizontal. It strikes the ground 3.00 s later.

- How far horizontally from the base of the building does the ball strike the ground? (4p)
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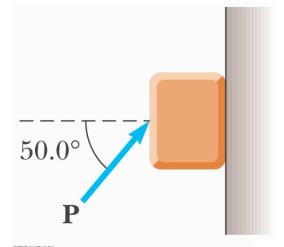
3. An air puck of mass $m_1 = 0.080 \text{ kg}$ is tied to a string and allowed to revolve in a circle of radius $R = 0.4 \text{ m}$ on a frictionless horizontal table. The other end of the string passes through a hole in the center of the table, and a counterweight of mass $m_2 = 0.200 \text{ kg}$ is tied to it. The suspended object remains in equilibrium while the puck on the tabletop revolves.

- draw free body diagram for the puck and the hanging mass (2p)
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- find the speed of the puck? (1p)

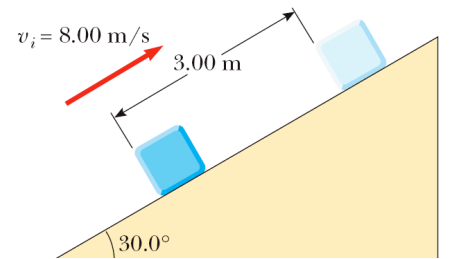


4. A block of mass 1.00 kg is pushed up against a wall

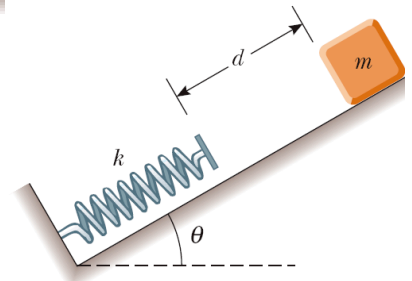
by a force P that makes a 50.0° angle with the horizontal as shown in Figure. The coefficient of static friction between the block and the wall is 0.220. Determine the maximum value for the magnitude of P that allow the block to remain stationary.



5. A 4.00-kg block is set into motion up an inclined plane with an initial speed of 8.00 m/s (Fig. P7.25). The block comes to rest after traveling 3.00 m along the plane, which is inclined at an angle of 30.0° to the horizontal. For this motion, determine (a) the change in the block's kinetic energy, (b) the change in the potential energy of the block-Earth system, and (c) the friction force exerted on the block (assumed to be constant). (d) What is the coefficient of kinetic friction?



5. An object of mass $m = 2 \text{ kg}$ starts from rest and slides a distance d down a frictionless incline of angle $\theta = 12 \text{ degrees}$. While sliding, it contacts an unstressed spring of negligible mass as shown in The object slides an additional distance $x = 2 \text{ cm}$ as it is brought momentarily to rest by compression of the spring (of force constant $k = 2000 \text{ N/m}$). Find the initial separation d between the object and the spring.





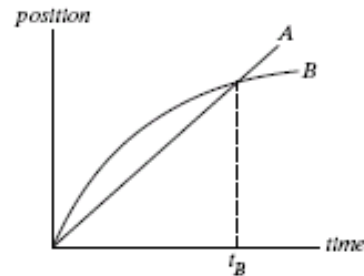
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3. A 4.0 kg mass starts from rest and is acted on by a constant net force. If the mass moves 64 m in 4.0 s, what is the force in N?

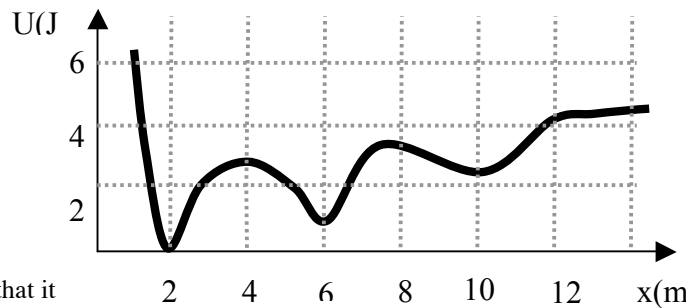
- a. 4
- b. 8
- c. 16
- d. 32
- e. 64

4 A bucket tied at the end of a 6.53m long string is whirled in a vertical circle with a constant speed. What should be the minimum speed of the bucket, so that the water from the bucket does not spill when the bucket is (upside down) at the highest position?

- a. 7
- b. 8
- c. 9
- d. 10
- e. none of the above

5 At $t=0$ particle is at rest $x=12\text{m}$. After its release it can move under influence of conservative force whose potential energy is shown in the diagram. What is the kinetic energy of this particle when its position $x=2\text{m}$?

- a. 4 J
- b. 2 J
- c. 1 J
- d. 0 J
- e. none of the above

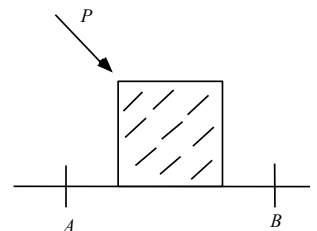


6 A train slows down as it rounds a sharp horizontal turn, slowing at constant rate from 30.0 m/s to 15. m/s in the 5.0 s that it takes to round the bend. The radius of the curvature of the bend is 100 m. Compute the magnitude of acceleration (in m/s^2) at the moment the train speed reaches 20.0 m/s.

- a. 0
- b. 1.51
- c. 2.23
- d. 5.00
- e. none of the above

7. A block is pushed across a rough horizontal surface from point A to point B by a force (magnitude $P = 5.4 \text{ N}$) as shown in the figure. The magnitude of the force of friction acting on the block between A and B is 1.2 N and points A and B are 2.0m apart. If the kinetic energies of the block at A and B are 4.0 J and 5.6 J, respectively, how much work in J is done on the block by the force P between A and B?

- a. 4.8
- b. 4.0
- c. 2.8
- d. 3.2
- e. none of the above



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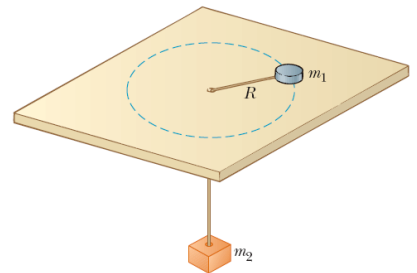
- determine the time interval required for the police officer to reach the motorist. (4p)
- find the speed of the officer as he overtakes the motorist (4p)
- the total displacement of the officer as he overtakes the motorist. (2p)

2. A ball is tossed from an upper-story window of a building. The ball is given an initial velocity of 7.00 m/s at an angle of 15.0° below the horizontal. It strikes the ground 4.00 s later.

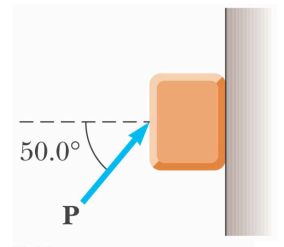
- How far horizontally from the base of the building does the ball strike the ground? (4p)
- Find the height from which the ball was thrown. (4p)
- What is the kinetic energy of the ball when it hits the ground (2p)

3. An air puck of mass $m_1 = 0.090 \text{ kg}$ is tied to a string and allowed to revolve in a circle of radius $R = 0.3 \text{ m}$ on a frictionless horizontal table. The other end of the string passes through a hole in the center of the table, and a counterweight of mass $m_2 = 0.150 \text{ kg}$ is tied to it. The suspended object remains in equilibrium while the puck on the tabletop revolves.

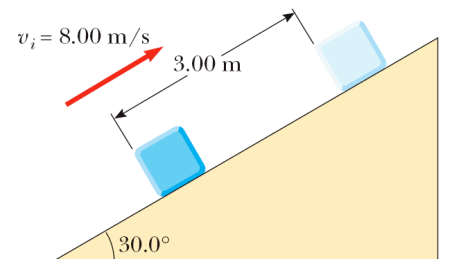
- draw free body diagram for the puck and the hanging mass (2p)
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- find the speed of the puck? (1p)



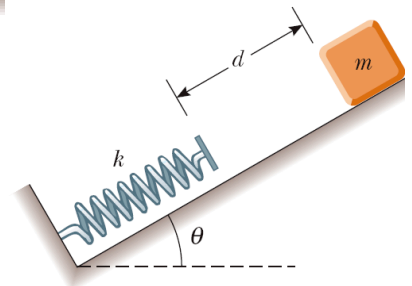
4. A block of mass 2.00 kg is pushed up against a wall by a force P that makes a 50.0° angle with the horizontal as shown in Figure. The coefficient of static friction between the block and the wall is 0.18. Determine the maximum value for the magnitude of P that allow the block to remain stationary.



5. A 3.00-kg block is set into motion up an inclined plane with an initial speed of 8.00 m/s (Fig. P7.25). The block comes to rest after traveling 3.00 m along the plane, which is inclined at an angle of 30.0° to the horizontal. For this motion, determine (a) the change in the block's kinetic energy, (b) the change in the potential energy of the block-Earth system, and (c) the friction force exerted on the block (assumed to be constant). (d) What is the coefficient of kinetic friction?



5. An object of mass $m = 1 \text{ kg}$ starts from rest and slides a distance d down a frictionless incline of angle $\theta = 18 \text{ degrees}$. While sliding, it contacts an unstressed spring of negligible mass as shown. The object slides an additional distance $x = 4 \text{ cm}$ as it is brought momentarily to rest by compression of the spring (of force constant $k = 1000 \text{ N/m}$). Find the initial separation d between the object and the spring.



SOLUTIONS TO ONE VERSION OF THE PHY1321 midterm long problems

1

Distance traveled by motorist = $(15.0 \text{ m/s})t$

Distance traveled by policeman = $\frac{1}{2}(2.00 \text{ m/s}^2)t^2$

(a) intercept occurs when $15.0t = t^2$, or $t = \boxed{15.0 \text{ s}}$

(b) $v(\text{officer}) = (2.00 \text{ m/s}^2)t = \boxed{30.0 \text{ m/s}}$

(c) $x(\text{officer}) = \frac{1}{2}(2.00 \text{ m/s}^2)t^2 = \boxed{225 \text{ m}}$

2

(a) $x_f = v_{xi} t = 8.00 \cos 20.0^\circ (3.00) = \boxed{22.6 \text{ m}}$

(b) Taking y positive downwards, and the final point just before ground impact,

$$y_f = v_{yi}t + \frac{1}{2}gt^2$$

$$y_f = 8.00 \sin 20.0^\circ (3.00) + \frac{1}{2}(9.80)(3.00)^2 = \boxed{52.3 \text{ m}}.$$

(c) $K_f = K_i + U = \frac{1}{2}mv^2 + mgy_f = 0.5 (0.2\text{kg})(64\text{m}^2/\text{s}^2) + 0.2(9.8) (52.3)\text{J}$

3 DGD Problem

a)



(b) Since the object of mass m_2 is in equilibrium,

$$\sum F_y = T - m_2g = 0$$

or

$$T = \boxed{m_2g}.$$

puck m_1 is experiencing radial acceleration so

$$\sum F_y = 0$$

$$\sum F_r = ma$$

$$F_c = T = m_1 a_c = \frac{m_1 v^2}{R}$$

(c) The tension in the string provides the required centripetal acceleration of the puck.

Thus, $F_c = T = \boxed{m_2g}$.

(d) From $F_c = T = m_2g$

(e) we have

$$F_c = T = m_2g = \frac{m_1 v^2}{R} \Rightarrow v = \boxed{\sqrt{\left(\frac{m_2}{m_1}\right)gR}}.$$

4 SOLVED IN CLASS

(Case 1, impending upward motion)

Setting

$$\begin{aligned} \sum F_x = 0: \quad P \cos 50.0^\circ - n &= 0 \\ f_{s, \max} = \mu_s n: \quad f_{s, \max} &= \mu_s P \cos 50.0^\circ \\ &= 0.250(0.643)P = 0.161P \end{aligned}$$

Setting

$$\begin{aligned} \sum F_y = 0: \quad P \sin 50.0^\circ - 0.161P - 3.00(9.80) &= 0 \\ P_{\max} &= \boxed{48.6 \text{ N}} \end{aligned}$$

(Case 2, impending downward motion)

As in Case 1,

$$f_{s, \max} = 0.161P$$

Setting

$$\begin{aligned} \sum F_y = 0: \quad P \sin 50.0^\circ + 0.161P - 3.00(9.80) &= 0 \\ P_{\min} &= \boxed{31.7 \text{ N}} \end{aligned}$$

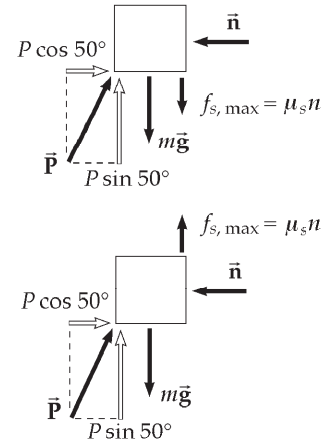


FIG. P5.13

5 DGD PROBLEM

(a) $\Delta K = \frac{1}{2} m (v_f^2 - v_i^2) = -\frac{1}{2} m v_i^2 = \boxed{-160 \text{ J}}$

(b) $\Delta U = mg(3.00 \text{ m}) \sin 30.0^\circ = \boxed{73.5 \text{ J}}$

(c) The mechanical energy converted due to friction is 86.5 J

$$f = \frac{86.5 \text{ J}}{3.00 \text{ m}} = \boxed{28.8 \text{ N}}$$

(d) $f = \mu_k n = \mu_k mg \cos 30.0^\circ = 28.8 \text{ N}$

$$\mu_k = \frac{28.8 \text{ N}}{(5.00 \text{ kg})(9.80 \text{ m/s}^2) \cos 30.0^\circ} = \boxed{0.679}$$

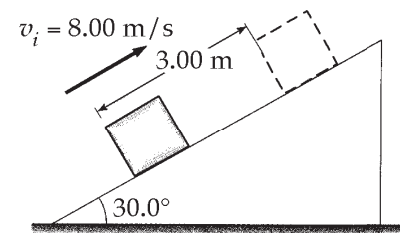


FIG. P7.25

6

Choose the zero point of gravitational potential energy of the object-spring-Earth system as the configuration in which the object comes to rest. Then because the incline is frictionless, we have $E_B = E_A$: $K_B + U_{gB} + U_{sB} = K_A + U_{gA} + U_{sA}$ or

$$0 + mg(d+x)\sin\theta + 0 = 0 + 0 + \frac{1}{2}kx^2. \text{ Solving for } d \text{ gives } d = \boxed{\frac{kx^2}{2mg\sin\theta} - x}.$$