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AP Physics C
Work HO11

1.) Rat pushes a 25.0 kg crate a distance of 6.0 m along a level floor at constant velocity by pushing horizontally on it. The coefficient of kinetic friction between the crate and floor is 0.30. (6-2)

a.) What magnitude of force must Rat apply?

b.) How much work is done on the crate by this force?

c.) How much work is done on the crate by friction?

d.) How much work is done by the normal force?

e.) What is the total work done on the crate?

2.) Suppose Larry pushes the same crate at an angle of 30° below the horizontal. (6-3)

a.) What magnitude of force must he apply to move the crate at constant velocity?

b.) How much work is done on the crate by this force when the crate is pushed a distance of 6.0 m?

c.) How much work is done by friction during this displacement?

3.) While water skiing, Rat is pulled behind a boat by a horizontal tow rope. She skies off to the side, so that the rope makes an angle of 15.0° with her direction of motion. The tension in the rope is 160 N. How much work is done on her by the rope during a displacement of 250 m? (6-4)

4.) Larry throws a fastball that leaves his paw at a speed of 36.0 m/s. The mass of the baseball is 0.145 kg. How much work has he done on the ball in throwing it? (6-13)

5.) A wagon with a mass of 6.00 kg moves in a straight line on a frictionless horizontal surface. It has an initial speed of 4.0 m/s and is then pushed 4.0 m in the direction of the initial velocity by a force with a magnitude of 10.0 N. Use the work-energy theorem to calculate the wagon's final speed. (6-15)

6.) A sled with a mass of 9.00 kg moves in a straight line on a frictionless horizontal surface. At one point in its path its speed is 4.00 m/s; after it has traveled 3.00 m beyond this point, its speed is 6.00 m/s. Use the work-energy theorem to find the force acting on the sled, assuming that this force is constant and that it acts in the direction of the sled's motion. (6-16)

7.) A 1.20 kg cat is dropped from the roof of a 30.0 m tall building. (6-18)

a.) Calculate the work done by gravity on the cat during its displacement from the roof to the ground.

b.) What is the velocity of the cat just before it hits the ground?

8.) A block of ice with mass 2.00 kg slides 0.70 m down a 30˚ inclined plane. If the block of ice starts from rest, what is its final speed? Friction can be neglected. (6-20)

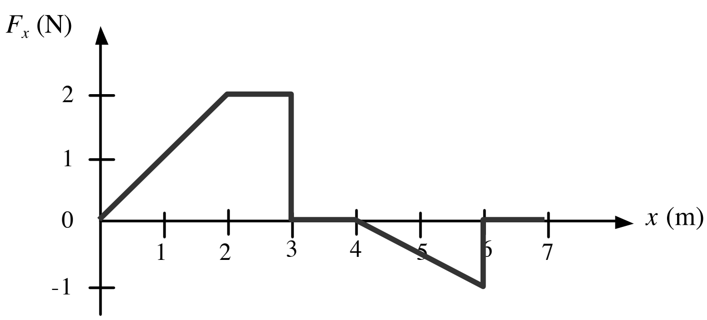
9.) To compress a spring 4.00 cm from its unstretched length, 12 J of work must be done. How much work must be done to stretch the same spring 3.00 cm from its unstretched length? (6-22)

10.) A force of 120 N stretches a spring 0.040 m beyond its unstretched length. (6-23)

a.) What magnitude of force is required to stretch the spring 0.010 m beyond its unstretched length? To compress the spring 0.080 m?

b.) How much work must be done to the spring in both cases?

11.)



Julia applies a force parallel to the x-axis to a sled moving on a frozen surface of a small pond. As she controls the speed of the sled, the x-component of the force she applies varies with the x-coordinate of the sled as shown in the figure to the left. Calculate the work done by the force when the sled moves (6-27)

a.) from $x = 0$ to $x = 3.0$ m

b.) from $x = 3.0$ m to $x = 4.0$ m

c.) from $x = 4.0$ m to $x = 7.0$ m

d.) from $x = 0$ to $x = 7.0$ m

12.) Suppose the sled in Problem 11 is initially at rest at $x = 0$ and that the mass of the sled is 12.0 kg. Use the work-energy theorem to find the speed of the sled at (6-30)

a.) $x = 3.0$ m

b.) $x = 4.0$ m

c.) $x = 7.0$ m

13.) A 3.00 kg block of ice is placed against a horizontal spring that has a spring constant of $k = 250$ N/m and is compressed 0.030 m. The spring is released and accelerates the block along a horizontal surface. Friction and the mass of the spring can be neglected. What is the speed of the block after it leaves the spring? (6-32)

14.) Rat and Larry are riding a two-cat bicycle and must overcome a force of 175 N to maintain a speed of 9.50 m/s. What is the power required per cat in horsepower? (6-35)

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AP Physics C
Work and Energy HO12

1.) Laura pulls a 20.0 kg suitcase up a ramp inclined at 25° above the horizontal by a force F of magnitude 145 N that acts parallel to the ramp. The coefficient of kinetic friction between the ramp and the incline is 0.30. If the suitcase travels 4.60 m along the ramp, calculate (6-47)

a.) the work done on the suitcase by the force F

b.) the work done on the suitcase by the gravitational force

c.) the work on the suitcase by the friction force

d.) the total work done on the suitcase

e.) If the speed of the suitcase is zero at the bottom of the ramp, what is its speed after it has traveled 4.60 m along the ramp?

2.) A 4.00 kg package slides 2.00 m down a long ramp that is inclined at 15.0° below the horizontal. The coefficient of kinetic friction between the package and the ramp is 0.35. Calculate (6-48)

a.) the work done on the package by friction

b.) the work done on the package by gravity

c.) If the package has a speed of 2.4 m/s at the top of the ramp, what is its speed after sliding 2.00 m down the ramp?

d.) If the package has a speed of 2.4 m/s at the top of the ramp, use the work-energy theorem to find out how far down the ramp the package slides before it stops.

3.) Susan stands in an elevator that has a constant upward acceleration while the elevator travels upward a distance of 15.0 m. During the 15.0 m displacement, the normal force exerted by the elevator floor does 8.25 kJ of work on her and gravity does –7.35 kJ of work on her. (6-50)

a.) What is Susan's mass?

b.) What is the normal force that the elevator floor exerts on her?

c.) What is the acceleration of the elevator?

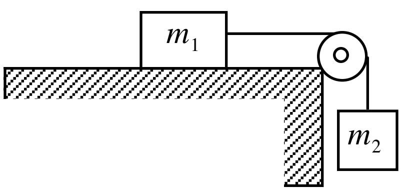
4.) The spring of a spring gun has a force constant of $k = 400$ N/m. The spring is compressed 0.0500 m and a ball with mass 0.0300 kg is placed in the horizontal barrel against the compressed spring. The spring is then released , and the ball is propelled out of the barrel of the gun. The barrel is 0.0500 m long, so the ball leaves the barrel at the same point at which it loses contact with the spring. (6-62)

a.) Calculate the speed with which the ball leaves the barrel if friction can be neglected.

b.) Calculate the speed of the ball as it leaves the barrel if a constant resisting force of 6.00 N acts on the ball as it moves along the barrel.

c.) For the situation in part (b.), at what position along the barrel does the ball have the greatest speed? What is that speed?

5.) Consider the system shown below. The rope and pulley have negligible mass, the pulley is frictionless, $m_1 = 8.00$ kg, and $m_2 = 6.00$ kg. The coefficient of kinetic friction between the 8.00 kg block and the table is 0.30. The blocks are released at rest. Use energy methods to calculate the speed of the 6.00 kg block after it has descended 2.50 m. (6-70)



6.) In the system above, the 6.00 kg block is initially moving downward, and the 8.00 kg block is initially moving to the right with a speed of 2.00 m/s. The blocks come to rest after moving 2.95 m. Use energy methods to calculate the coefficient of kinetic friction between the 8.00 kg block and the table top. (6-71)

7.) A block of mass 1.50 kg is forced against a horizontal spring of negligible mass, compressing it a distance of 0.200 m. The force constant of the spring is $k = 250$ N/m. When released, the block slides on a horizontal table top with coefficient of kinetic friction 0.30. Use energy methods to find how far the block moves from its initial position before coming to rest. (6-65)

8.) The only force acting on a 2.0 kg body as it moves along the positive x-axis has an x component $F_x = -6x$ N, where x is in meters. The velocity of the body at $x = 3.0$ m is 8.0 m/s. (??)

a.) What is the velocity of the body at $x = 4.0$ m?

b.) At what positive value of x will the body have a velocity of 5.0 m/s?

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AP Physics C
Work and Energy HO13

1.) A block of ice with mass 6.00 kg is initially at rest on a frictionless horizontal surface. Rat then applies a horizontal force F to it. As a result, the block moves along the x-axis such that its position as a function of time is given by $x(t) = \alpha t^2 + \beta t^3$, where $\alpha = 2.00\ \text{m/s}^2$ and $\beta = 0.200\ \text{m/s}^3$. (6-59)

a.) Calculate the velocity of the object when $t = 4.00$ s.

b.) Calculate the magnitude of F when $t = 4.00$ s.

c.) Calculate the work done by the force F during the first 4.00 s of the motion.

2.) A 5.00 kg block is moving at $v_o = 6.00$ m/s along a frictionless horizontal surface toward a spring with a force constant $k = 500$ N/m that is attached to a wall. The spring has negligible mass. (6-68)

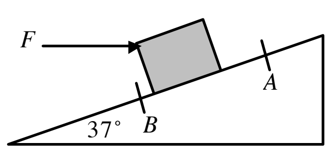
a.) Find the maximum distance the spring will be compressed.

b.) If the spring is to be compressed by no more than 0.200 m, what should be the maximum value of v_0?

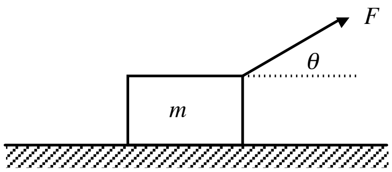
3.) At a water park, sleds with riders are sent along a slippery horizontal surface by the release of a large compressed spring. The spring with a force constant $k = 4000$ N/m and negligible mass rests on a frictionless horizontal surface. One end is in contact with a stationary wall; a sled and rider with total mass 80.0 kg are pushed against the other end, compressing the spring 0.375 m. The sled is then released with zero initial velocity. What is the sled's speed when the spring returns to its uncompressed length? (6-29)

4.) What must be the power output of an elevator motor that can lift a total mass of 1000 kg and give the elevator a constant speed of 8.0 m/s? (??)

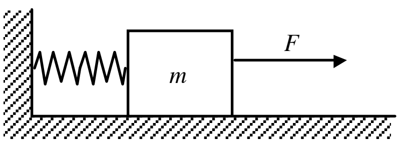
5.) A 4.0 kg block is lowered down a 37˚ incline a distance of 5.0 m from point A to point B. A horizontal force (F = 10 N) is applied to the block between A and B as shown in the figure below. The kinetic energy of the block at A is 10 J and at B it is 20 J. How much work is done on the block by the force of friction between A and B? (STB-7-15)



6.) A 3.0 kg block is dragged over a rough horizontal surface by a constant force of 16 N acting at an angle of 37˚ as shown below. The speed of the block increases from 4.0 m/s to 6.0 m/s in a displacement of 5.0 m. What work was done by the frictional force during this displacement? (STB-7-22)



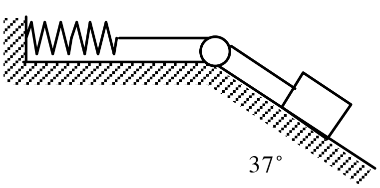
7.) A 10 kg block on a horizontal frictionless surface is attached to a spring with force constant k = 800 N/m. The block is initially at rest at its equilibrium position when an 80 N force acting parallel to the surface is applied to the block, as shown below. What is the speed of the block when it is 13 cm from its equilibrium position? (STB-7-34)



8.) Starting from rest at t = 0, a 5.0 kg block is pulled across a horizontal surface by a constant horizontal force having a magnitude of 12 N. If the coefficient of kinetic friction between the block and the surface is 0.20. at what rate is the 12 N force doing work at t = 5.0 s? (STB-7-33)

9.) A block is attached to the spring. The horizontal surface on which the block slides is frictionless. If k = 1000 N/m, m = 2.0 kg, and the speed of the block as it slides through the equilibrium position is equal to 5.0 m/s, what is the kinetic energy of the block after it slides 20 cm beyond the equilibrium position? (STB-7-38)

10.) A 2.0 kg block situated on a frictionless incline is connected to a spring (k = 100 N/m), as shown below. The block is released from rest when the spring is unstretched. The pulley is frictionless and has negligible mass. What is the speed of the block when its has moved 0.20 m down the plane? (STB-7-40)



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AP Physics C
Potential Energy HO14

1.) A baseball is thrown from the roof of a 27.5 m tall building with an initial velocity of magnitude 16.0 m/s and directed at an angle of 37.0˚ above the horizontal. What is the speed of the ball just before it strikes the ground? (Use energy methods 7-3.)

2.) Larry throws a 0.145 kg baseball straight up in the air with an initial speed of 20.0 m/s. Use conservation of energy to find how high the baseball goes. (Ex 7-1)

3.) A 12 kg crate is at the bottom of a 2.5 m ramp inclined at 30˚. Rat gives it an initial speed of 5.0 m/s and the crate slides 1.6 m up the ramp, stops and slides back down. (Ex 7-7 7-8 ab)

a.) Assuming that the friction force acting on the crate is constant, find its magnitude.

b.) How fast is the crate moving when it reaches the bottom of the ramp?

c.) What is the minimum initial speed required for the crate to reach the top of the ramp?

d.) If the initial speed of the crate is 10.0 m/s, what is its speed at the top of the ramp?

4.) A 12.0 kg box is pushed 14.0 m up a ramp inclined at an angle of 37˚ above the horizontal, by a constant force **F** with a magnitude of 120 N and acting parallel to the ramp. The coefficient of kinetic friction between the box and the ramp is 0.25. (7-11)

a.) What is the work done on the box by the force **F**?

b.) What is the work on the box done by the friction force?

c.) Compute the increase in potential energy for the box.

d.) Use these results to calculate the increase in the box's kinetic energy.

e.) Use Newton's 2^{nd} law to calculate the acceleration of the box.

f.) Assuming that the box is initially at rest, use the acceleration to calculate the box's speed after traveling 14.0 m.

g.) Use the result of part (f.) to find the increase in kinetic energy of the box and compare to answer found in part (d.).

5.) A 1.20 kg book is dropped from a height of 0.80 m onto a spring with a force constant of k = 1960 N/m and negligible mass. Find the maximum distance the spring will be compressed. (7-15)

6.) A brick with mass 1.60 kg is placed on a vertical spring with force constant k = 1500 N/m that is compressed 0.20 m. When the spring is released, how high does the brick rise above the uncompressed spring? (7-17)

7.) A sled with mass m = 0.200 kg sits on a frictionless horizontal track and is connected to a spring with force constant k = 5.00 N/m. The sled is pulled, stretching the spring 0.100 m and then released with no initial velocity. (Ex 7-8)

a.) What is its velocity when x = 0.080 m?

b.) What is its velocity when it returns to x = 0.0 m? (7-19a)

c.) What must be the initial displacement of the sled if its maximum speed in the subsequent motion is to be 2.00 m/s? (7-19b)

d.) What is the displacement of the sled from its equilibrium position when its speed is 0.40 m/s? (7-20)

e.) Suppose the track is not frictionless. What must be the coefficient of kinetic friction between the sled and the track so that the sled reaches the x = 0 position with zero speed? (7-22)

8.) A 2.00 kg block is pushed against a spring with negligible mass and force constant k = 400 N/m, compressing it 0.220 m. When the block is released, it moves along a frictionless horizontal surface and then up a frictionless incline with slope 37.0°. (7-40)

a.) What is the speed of the block as it slides along the horizontal surface after having left the spring?

b.) How far does the block travel up the incline before starting to slide back down?

9.) A block with a mass 0.50 kg is forced against a horizontal spring of negligible mass, compressing the spring a distance of 0.20 m. When released, the block moves on a horizontal table top for 1.00 m before coming to rest. The spring constant is k = 100 N/m. What is the coefficient of kinetic friction between the block and the table? (7-41)

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AP Physics C
Potential Energy HO15

1.) A 0.50 kg book moves vertically upward a distance of 12 m and then vertically downward 12 m, returning to its initial position. (7-25)

a.) How much work is done by gravity during the upward motion of the book?

b.) How much work is done by gravity during the downward motion of the book?

c.) What is the total work done by gravity during the complete round trip?

d.) Is the gravitational force conservative or nonconservative?

2.) A 0.50 kg book slides on a horizontal table top. The kinetic friction force on the block has a magnitude 1.2 N. (7-29)

a.) How much work is done on the block by friction during a displacement of 4.0 m to the right?

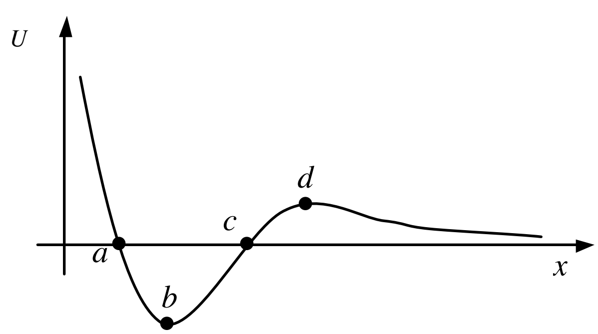
b.) The book now slides 4.0 m to the left, returning to its starting point. During this second 4.0 m displacement, how much work is done on the book by friction?

c.) What is the total work done on the book by friction during the complete round trip?

d.) Is the frictional force conservative or nonconservative?

3.) A force parallel to the x-axis acts on a particle moving along the x-axis. This force produces a potential energy $U(x)$ given by $U(x) = \alpha x^3$, where $\alpha = 2.5$ J/m^3. What is the force (magnitude and direction) when the particle is at $x = 1.60$ m? (7-34)

4.) A marble moves along the x-axis. The potential energy function is shown below. (7-38)

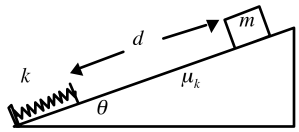


a.) At which of the labeled points is the force on the marble zero? Explain your answer.

b.) Which of the labeled x-coordinates is a position of stable equilibrium? Explain your answer.

c.) Which of the labeled x-coordinates is a position of unstable equilibrium? Explain your answer.

5.) A 90.0 kg man jumps from a height of 2.50 m onto a platform mounted on springs. As the springs compress, the platform is pushed down a maximum distance of 0.200 m below its initial position, and then rebounds. What is the man's speed at the instant the platform is depressed 0.100 m? (7-60)

6.) 

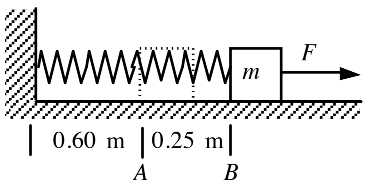
A 2.00 kg package is released on a 53.1° incline, 4.00 m from a long spring with force constant k = 140 N/m that is attached at the bottom of the incline. The coefficient of kinetic friction is 0.20 and the mass of the spring is negligible. (7-64)

a.) What is the speed of the package just before it reaches the spring?

b.) What is the maximum compression of the spring?

c.) The package rebounds back up the incline. How close does it get to its initial position?

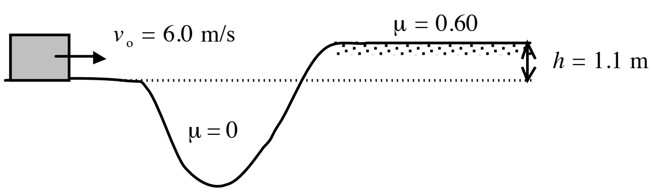
7.) A 0.500 kg block attached to a spring with length 0.60 m and force constant k = 40.0 N/m is at rest with the back of the block at point A on a frictionless, horizontal table. The mass of the spring is negligible. You pull the block to the right along the surface with a constant horizontal force F = 20.0 N. (7-65)



a.) What is the block's speed when the back of the block reaches point B?

b.) When the back of the block reaches point B, you let go of the block. In the subsequent motion, how far does the block get from the wall where the left end of the spring is attached?

c.) How close does the block get to the wall where the left end of the spring is attached?

8.) 

A block slides along a track from one level to a higher level, by moving through an intermediate valley. The track is frictionless until the block reaches the higher level. There a frictional force stops the block in a distance d. The block's initial speed v_o is 6.0 m/s; the height difference h is 1.1 m; and the coefficient of kinetic friction is 0.60. Find d. (??)

9.) A 0.200 kg ball is tied to a string with length 3.00 m, and the other end of the string is tied to a rigid support, The ball is held straight out horizontally from the point of support, with the string pulled taut, and is then released. (7-53)

a.) What is the speed of the ball at the lowest point of its motion?

b.) What is the tension in the string at this point?

10.) A certain spring is found not to obey Hooke's Law; it exerts a restoring force $F_x(x) = -\alpha x - \beta x^2$ if it is stretched or compressed, where $\alpha = 70.0$ N/m and $\beta = 12.0$ N/m^2. The mass of the spring is negligible. (7-61)

a.) Calculate the potential energy function $U(x)$ for this spring. Let $U = 0$ when $x = 0$.

b.) An object with a mass of 0.800 kg on a frictionless horizontal surface is attached to this spring, pulled a distance 1.00 m to the right (+x-direction) to stretch the spring, and released. What is the speed of the object when it is 0.50 m to the right of the $x = 0$ equilibrium position?