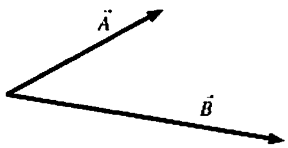
11 Work

11.2 Work and Kinetic Energy

11.3 Calculating and Using Work

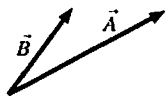
1. For each pair of vectors, is the sign of $\vec{A} \cdot \vec{B}$ positive (+), negative (–), or zero (0)?

a.



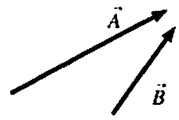
Sign = ____

b.



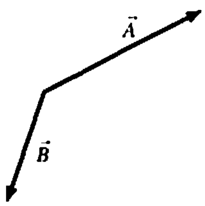
Sign = ____

c.



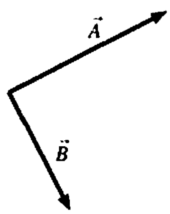
Sign = ____

d.



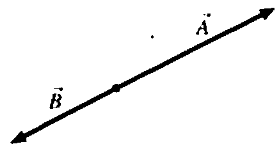
Sign = ____

e.



Sign = ____

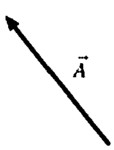
f.



Sign = ____

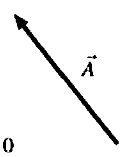
2. Each of the diagrams below shows a vector $\vec{A}$. Draw and label a vector $\vec{B}$ that will cause $\vec{A} \cdot \vec{B}$ to have the sign indicated.

a.



$\vec{A} \cdot \vec{B} > 0$

b.



$\vec{A} \cdot \vec{B} < 0$

c.

$\vec{A} \cdot \vec{B} = 0$

Exercises 3–10: For each situation:

- Draw a before-and-after pictorial diagram.
- Draw and label the displacement vector $\Delta\vec{r}$ on your diagram.
- Draw a free-body diagram showing *all* forces acting on the object.
- Make a table beside your diagrams showing the sign (+, –, or 0) of (i) the work done by each force seen in your free-body diagram, (ii) the net work W_{net}, and (iii) ΔK, the object's change in kinetic energy.

3. An elevator moves upward at constant speed.

4. A descending elevator brakes to a halt.

5. A box slides down a frictionless slope.

6. A box slides up a frictionless slope.

7. A ball is thrown straight up. Consider the ball from one microsecond after it leaves your hand until the highest point of its trajectory.

8. You toss a ball straight up. Consider the ball from the instant you begin moving your hand until you release the ball.

9. A car turns a corner at constant speed.

10. A flat block on a string swings once around a horizontal circle on a frictionless table. The block moves at steady speed.

11. A 0.2 kg plastic cart and a 20 kg lead cart both roll without friction on a horizontal surface. Equal forces are used to push both carts forward a distance of 1 m, starting from rest. After traveling 1 m, is the kinetic energy of the plastic cart greater than, less than, or equal to the kinetic energy of the lead cart? Explain.

12. Particle A has less mass than particle B. Both are pushed forward across a frictionless surface by equal forces for 1 s. Both start from rest.

a. Compare the amount of work done on each particle. That is, is the work done on A greater than, less than, or equal to the work done on B? Explain.

b. Compare the impulses delivered to particles A and B. Explain.

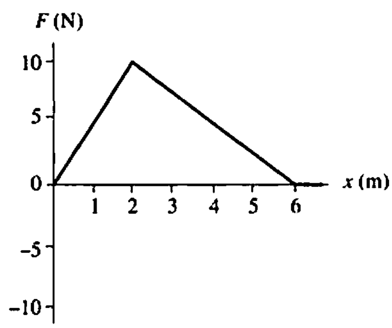
c. Compare the final speeds of particles A and B. Explain.

11.4 The Work Done by a Variable Force

13. In Chapter 9, we found a graphical interpretation of Δp as the area under the F-versus-t graph from an initial time t_i to a final time t_f. Provide an analogous graphical interpretation of ΔK, the change in kinetic energy.

14. A particle moving along the x-axis experiences the forces shown below. How much work does each force do on the particle? What is each particle's change in kinetic energy?

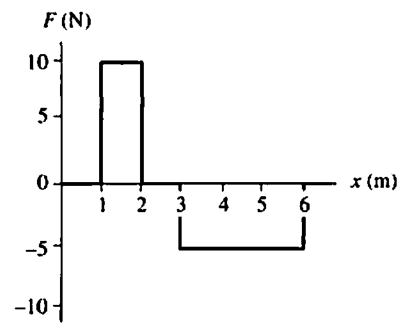
a.



$W =$ ______

$\Delta K =$ ______

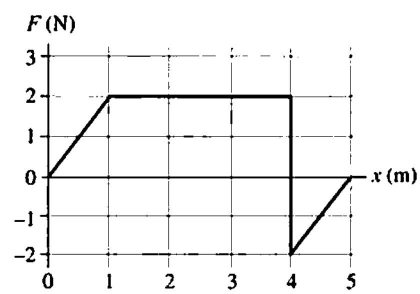
b.



$W =$ ______

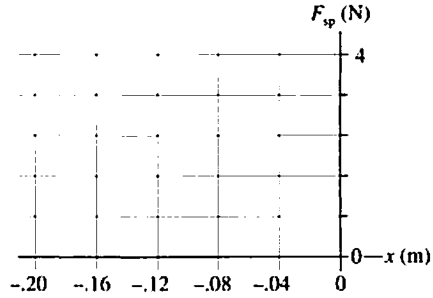
$\Delta K =$ ______

15. A 1 kg particle moving along the x-axis experiences the force shown in the graph. If the particle's speed is 2 m/s at $x = 0$ m, what is its speed when it gets to $x = 5$ m?



16. In Example 11.8 in the textbook, a compressed spring with a spring constant of 20 N/m expands from $x_0 = -20$ cm $= -0.20$ m to its equilibrium position at $x_1 = 0$ m.

a. Graph the spring force F_{sp} from $x_1 = -0.20$ m to $x_2 = 0$ m.



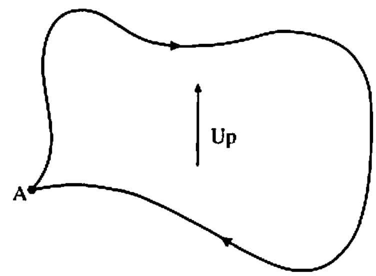
b. Suppose the surface had been frictionless. Use your graph to determine ΔK, the change in a cube's kinetic energy when launched by a spring that has been compressed by 20 cm.

c. Use your result from part b to find the launch speed of a 100 g cube in the absence of friction. Compare your answer to the value found in the Example 11.8. Why are they different?

11.5 Force, Work, and Potential Energy

11.6 Finding Force from Potential Energy

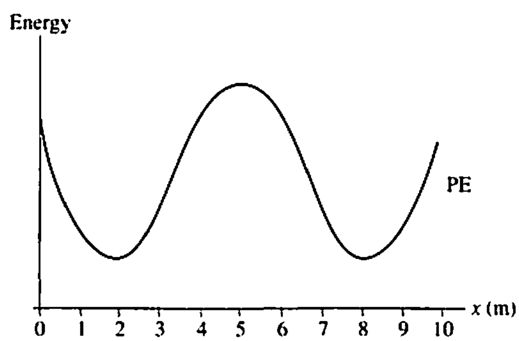
17. A particle moves in a vertical plane along a *closed* path, starting at A and eventually returning to its starting point. How much work is done on the particle by gravity? Explain.



18. a. If the force on a particle at some point in space is zero, must its potential energy also be zero at that point? Explain.

b. If the potential energy of a particle at some point in space is zero, must the force on it also be zero at that point? Explain.

19. The graph shows the potential-energy curve of a particle moving along the x-axis under the influence of a conservative force.



a. In which intervals of x is the force on the particle to the right?

b. In which intervals of x is the force on the particle to the left?

c. At what value or values of x is the magnitude of the force a maximum?

d. What value or values of x are positions of stable equilibrium?

e. What value or values of x are positions of unstable equilibrium?

f. If the particle is released from rest at $x = 0$ m, will it reach $x = 10$ m? Explain.

11.7 Thermal Energy

20. A ball of clay traveling at 10 m/s slams into a wall and sticks. What happened to the kinetic energy the clay had just before impact?

21. What energy transformations occur as a box slides up a gentle but slightly rough incline until stopping at the top?

11.8 Conservation of Energy

22. Give a *specific* example of a situation in which:

a. $W_{ext} \rightarrow K$ with $\Delta U = 0$ and $\Delta E_{th} = 0$.

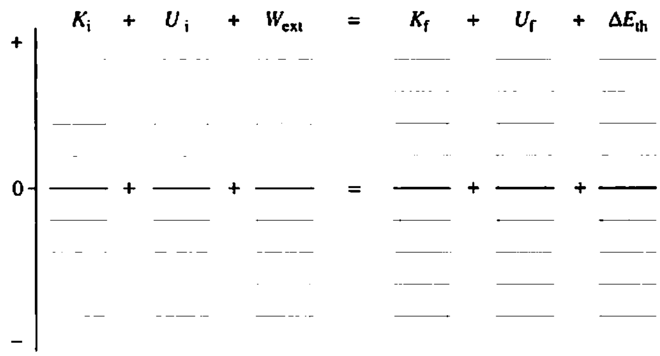
b. $W_{ext} \rightarrow U$ with $\Delta K = 0$ and $\Delta E_{th} = 0$.

c. $K \rightarrow U$ with $W_{ext} = 0$ and $\Delta E_{th} = 0$.

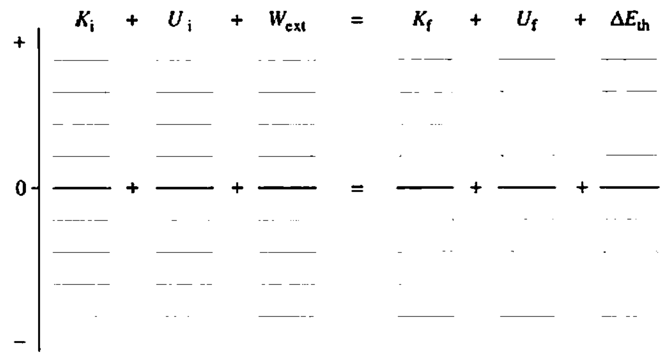
d. $W_{ext} \rightarrow E_{th}$ with $\Delta K = 0$ and $\Delta U = 0$.

e. $U \rightarrow E_{th}$ with $\Delta K = 0$ and $W_{ext} = 0$.

23. A system loses 1000 J of potential energy. In the process, it does 500 J of work on the environment and the thermal energy increases by 250 J. Show this process on an energy bar chart.



24. A system gains 1000 J of kinetic energy while losing 500 J of potential energy. The thermal energy increases by 250 J. Show this process on an energy bar chart.



25. A box is sitting at the top of a ramp. An external force pushes the box down the ramp, causing it to slowly accelerate. Show this process on an energy bar chart.

11.9 Power

26. a. If you push an object 10 m with a 10 N force in the direction of motion, how much work do you do on it?

b. How much power must you provide to push the object in 1 s? In 10 s? In 0.1 s?