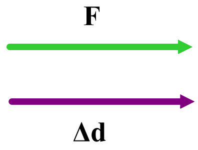
Positive and Negative Work
(Page 233)

Positive work is done when the force causing the displacement is in the **same** direction as the displacement. Positive work **adds** energy to an object.

Negative work is done when the force causing the displacement is in a direction **opposite** that of the displacement. Negative work **removes** energy from an object.

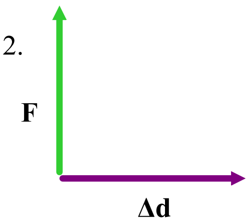
Examples

1.



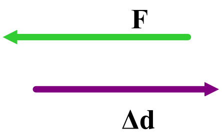
Maximum Positive Work

2.



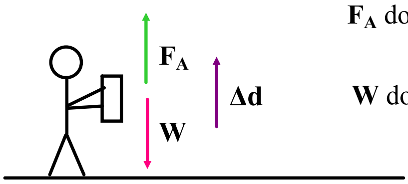
No Work is Done

3.



Maximum Negative Work

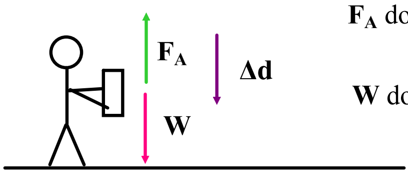
4.



F_A does positive work.

W does negative work.

5.



F_A does negative work.

W does positive work.

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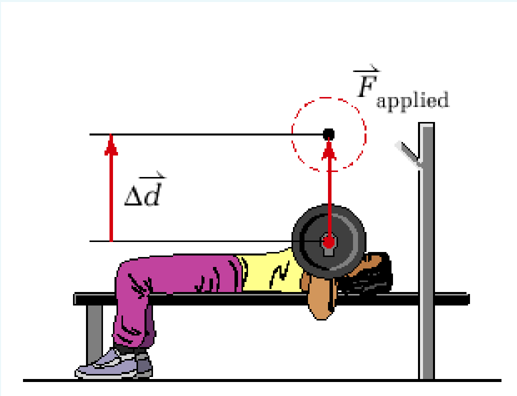
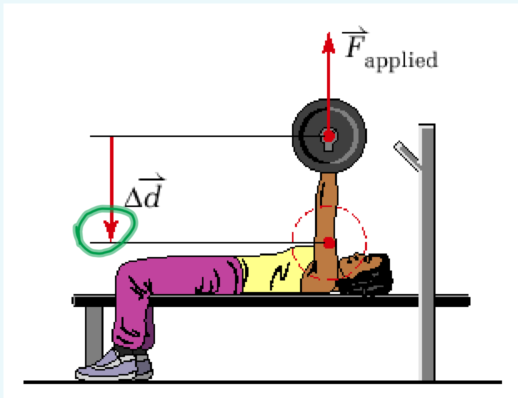
MODEL PROBLEM

Doing Positive and Negative Work

Consider a weight lifter bench-pressing a barbell weighing 6.50×10^2 N through a height of 0.55 m. There are two distinct motions: (1) when the barbell is lifted up and (2) when the barbell is lowered back down. Calculate the work that the weight lifter does on the barbell during each of the two motions.





Lifting

W = Fd
W = (6.50 x 10^2 N)(0.55 m)
W = 3.2 x 10^2 J

F ↑ ↑ **Δd**

W = 3.2 x 10^2 J

Lowering

W = Fd
W = (6.50 x 10^2 N)(0.55 m)
W = 3.2 x 10^2 J

F ↑ ↓ **Δd**

W = - 3.2 x 10^2 J

PRACTICE PROBLEMS

14. A large statue, with a mass of 180 kg, is lifted through a height of 2.33 m onto a display pedestal. It is later lifted from the pedestal back to the ground for cleaning.

(a) Calculate the work done by the applied force on the statue when it is being lifted onto the pedestal.

(b) Calculate the work done by the applied force on the statue when it is lowered down from the display pedestal.

(c) State all of the forces that are doing work on the statue during each motion.

15. A mechanic exerts a force of 45.0 N to raise the hood of a car 2.80 m. After checking the engine, the mechanic lowers the hood. Find the amount of work done by the mechanic on the hood during each of the two motions.

Kinetic Energy
(Page 236)

Reminder: Kinetic energy is energy due to motion.

Check Units

$$E_k = \frac{1}{2}mv^2$$

$Kg \left(\frac{m}{s}\right)^2$

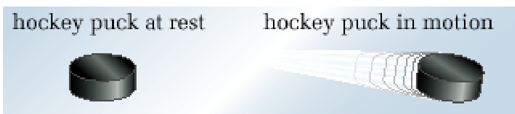
E_k -> kinetic energy (J)
m -> mass (kg)
v -> velocity (m/s)

NOTE: When velocity is squared, it is no longer a vector so no vector notation is used in the kinetic energy equation.

MODEL PROBLEM

Calculating Kinetic Energy

A 0.200 kg hockey puck, initially at rest, is accelerated to 27.0 m/s. Calculate the kinetic energy of the hockey puck (a) at rest and (b) in motion.



(a) $\vec{v}_1 = 0$ (b) $\vec{v}_2 = 27.0\,\frac{m}{s}$

$E_k = 0$ J $\quad E_k = 72.9$ J

$E_k = 0J$
$\frac{1}{2}(.2)(0)^2$

$E_k = \frac{1}{2}(.2)(27)^2$
$= 72.9J$

PRACTICE PROBLEMS

19. A 0.100 kg tennis ball is travelling at 145 km/h. What is its kinetic energy? 81J
20. A bowling ball, travelling at 0.95 m/s, has 4.5 J of kinetic energy. What is its mass? 10 Kg
21. A 69.0 kg skier reaches the bottom of a ski hill with a velocity of 7.25 m/s. Find the kinetic energy of the skier at the bottom of the hill. 1810 J

20) $4.5 = \frac{1}{2}m(0.95)^2$

Work-Kinetic Energy Theorem
(Page 239)

The special relationship between doing work on an object and the resulting kinetic energy of the object is given by the work-kinetic energy theorem.

Assumptions:
- all work done on a system gives the system only kinetic energy
- a constant force gives the system a constant acceleration
- directions of force and displacement are parallel
- the object moves in a straight line

$$W = Fd$$

$$W = (ma)d$$

$$W = m\left(\frac{v_f - v_i}{t}\right)d$$

Note: $d = \frac{1}{2}(v_f + v_i)\,t$

$$W = m\frac{(v_f - v_i)}{\cancel{t}}\,\frac{1}{2}(v_f + v_i)\cancel{t}$$

$$W = \frac{1}{2}m\,(v_f - v_i)(v_f + v_i)$$

$$W = \frac{1}{2}m\,(v_f^2 - v_i^2)$$

$$W = \frac{1}{2}mv_f^2 - \frac{1}{2}mv_i^2$$

$$W = E_{kf} - E_{ki}$$

$$W = \Delta E_k$$

also

$$Fd = \Delta E_k$$

The equation describes how doing work on an object can change the object's kinetic energy.

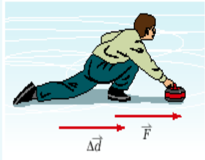
MODEL PROBLEMS

Applying the Work-Kinetic Energy Theorem

1. A physics student does work on a 2.5 kg curling stone by exerting 4.0×10^1 N of force horizontally over a distance of 1.5 m.

   (a) Calculate the work done by the student on the curling stone.

   (b) Assuming that the stone started from rest, calculate the velocity of the stone at the point of release. (Consider the ice surface to be effectively frictionless.)



a) 60 J
b) +6.9 m/s

2. A 75 kg skateboarder (including the board), initially moving at 8.0 m/s, exerts an average force of 2.0×10^2 N by pushing on the ground, over a distance of 5.0 m. Find the new kinetic energy of the skateboarder if the trip is completely horizontal.

3.4×10^3 J

A skateboarder does work by pushing on the ground. The work gives the skateboarder kinetic energy.

☆

PRACTICE PROBLEMS

22. A 6.30 kg rock is pushed horizontally across a 20.0 m frozen pond with a force of 30.0 N. Find the velocity of the rock once it has travelled 13.9 m. (Assume there is no friction.)
23. The mass of an electron is 9.1×10^{-31} kg. At what speed does the electron travel if it possesses 7.6×10^{-18} J of kinetic energy?
24. A small cart with a mass of 500 g is accelerated, uniformly, from rest to a velocity of 1.2 m/s along a level, frictionless track. Find the kinetic energy of the cart once it has reached a velocity of 1.2 m/s. Calculate the force that was exerted on the cart over a distance of 0.1 m in order to cause this change in kinetic energy.

25. A child's toy race car travels across the floor with a constant velocity of 2.10 m/s. If the car possesses 14.0 J of kinetic energy, find the mass of the car.