Work, Energy & Power

FORMULAS

$W = Fd$ $P = \frac{W}{t} = \frac{Fd}{t} = F\bar{v}$ $PE = mgh$ $KE = \frac{1}{2}mv^2$

1 hp = 746 watts

CONSERVATION OF MECHANICAL ENERGY

In the absence of friction, air resistance or other dissipative forces, the total mechanical energy (PE + KE) of a system remains constant.

$$PE_i + KE_i = PE_f + KE_f$$

WORK-ENERGY PRINCIPLE

The net work done on a body is equal to the change in KE or PE of the body.

$$\text{Work} = \Delta KE = \frac{1}{2}m(v_f^2 - v_i^2)$$
$$\text{Work} = \Delta PE = mg(h_f - h_i)$$

KILOWATT-HOURS

If the power output of a machine is measured in kilowatts, and its time of operation is in hours, the product of power and time would give the work in kilowatt-hours (kWh).

Example 1: How much gravitational potential energy is stored in a 12-kg ball that has been lifted 1.5 m?

Solution: $PE = mgh = (12\text{ kg})(10\ ^{m}/_{s})(1.5\text{ m}) = 180\text{ J}$

Example 2: Find the kinetic energy of a 5-kg object moving with a speed of 4 $^{m}/_{s}$.

Solution: $KE = \frac{1}{2}mv^2 = \frac{1}{2}(5\text{ kg})(4\ ^{m}/_{s^2})^2 = 40\text{ J}$

EXERCISES

A. What conditions must be met in order for work to be done?

B. Using a force of 85 N, you push a trunk 7.5 m across the floor. How much work do you do?

C. If you do 1450 J of work in carrying a load of books up a flight of stairs, covering a vertical distance of 15 m, what is the mass of the books?

D. What is the mass of a baseball that has 120 J of kinetic energy when it is going 25 $^{m}/_{s}$?

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E. How much power is needed to pump 50.5 kg of water up a vertical distance of 12.5 m in 11.5 s?

F. In how many seconds must an 85-kg man climb 6.0 m to his third floor apartment in order to expend power at a rate of 1 hp?

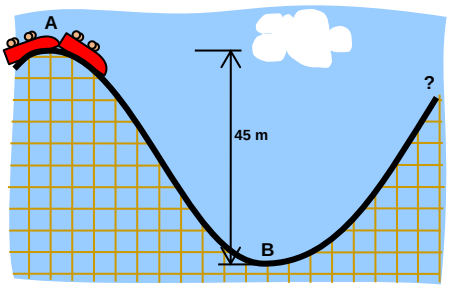
G. How much work is required to accelerate a 1500-kg automobile from 10.0 m/s to 20.0 m/s?

H. A stone having a mass of 5.0 kg is dropped from a height of 200 m. Calculate the PE and the KE of the stone:
1) at t = 0 2)at t = 5.0 s 3) when the stone strikes the ground

I. A pendulum is pulled to one side and released from a point 12.5 cm above is equilibrium position. Find the speed of the bob as it passes through the equilibrium position.

J. A plane airdrops a 91.5-kg anvil from a height of 0.535 km without a parachute. When it lands, it sinks into soft ground a distance of 2.75 m. What was the average retarding force of the ground? [*Hint: How fast was the anvil going when it collided with the ground?*]

K. A frictionless roller coaster starts from rest atop a 45-m hill (point A).
1) Determine the velocity of the roller coaster at the bottom of this hill (point B).
2) After passing through point B, the roller coaster climbs a second hill. At what height above point B will its speed be halved?



L. A student throws a 0.25-kg rock from the top of a 25-m building with a speed of 15.5 m/s. Find:
1) its kinetic energy when it lands 2) its speed when it lands

M. Convert the following:
1) 10.0 hp = _____ kW 2) 37.3 kW = _____ hp

N. At 5¢ per kWh, what does it cost to operate a 100-watt light bulb for 8 hours?

SOLUTIONS

A. Work is done when a force acts on a body and the body moves some distance.
B. 640 J C. 9.7 kg D. 0.38 kg E. 549 W F. 6.8 s G. 2.25×10^5 J
H. (1) PE = 1.0×10^4 J, KE = 0 J (2) PE = 3.8×10^3 J, KE = 6.3×10^3 J
(3) PE = 0 J, KE = 1.0×10^4 J
I. 1.6 m/s J. 1.74×10^5 N K. (1) 30 m/s (2) 34 m L. (1) 93 J (2) 27 m/s
M. (1) 7.46 kW (2) 50.0 hp N. 4¢