Work, Power & Energy Study Guide

What is the formula for Work? \[ W = F_r c \cos \theta \] What unit is Work measured in? \textit{Joules (J)}

What is the formula for Kinetic Energy? \[ K = \frac{1}{2} m v^2 \]

What is the formula for Gravitational Potential Energy? \[ U_g = m g h \]

What is the formula for Elastic Potential Energy? \[ U_s = \frac{1}{2} k x^2 \]

All types of energy are measured in: \textit{Joules}

What are the formulas for Power? \[ P = \frac{W}{t} \quad P = F_r v \]

Power is measured in: \textit{Watts}

If one of the variables in ANY of the equations we've studied changes, know how it affects the other variables?

Practice Problems

1. How much work is required to lift a 10-kilogram mass to a height of 46 meters?
   \[ W = F_r = (m) g h = 10(9.8)(46) = \boxed{4508 \text{ J}} \]

2. What force is required to do 120 joules of work in sliding an object a distance of 8 meters across a level floor?
   \[ F = \frac{W}{r} = \frac{120}{8} = \boxed{15 \text{ N}} \]

3. How much work will a 680-watt motor do in 5 seconds?
   \[ P = \frac{W}{t} \quad W = P t = (680)(5) = \boxed{3400 \text{ J}} \]

4. How long would it take a machine to do 13,000 joules of work if the power rating of the machine is 320 watts?
   \[ P = \frac{W}{t} \quad t = \frac{W}{P} = \frac{13000}{320} = \boxed{40.625 \text{ sec}} \]
5. Car A and car B of equal mass travel up a hill. Car A moves up the hill at a constant speed that is three times the constant speed of car B. Compared to the power developed by car B, what is the power developed by car A?

\[ \frac{v_A}{v_B} = \frac{3v}{v} \]

\[ P = Fv \]

Power of B is 3 time Power of A

6. A 120-kilogram person acquires a velocity of 21 meters per second down a ski slope. What is the skier’s kinetic energy?

\[ K = \frac{1}{2}mv^2 = \frac{1}{2} (120)(21)^2 = 26460 \text{ J} \]

7. What is the spring constant of a spring of negligible mass which gained 10 joules of potential energy as a result of being compressed 0.6 meter?

\[ U = \frac{1}{2} kx^2 \]

\[ k = \frac{2U}{x^2} = \frac{2(10)}{(0.6)^2} = \frac{55.6 \text{ N}}{m} \]

8. An object gains 15 joules of potential energy as it is lifted vertically 5.0 meters. If a second object with one-half the mass is lifted vertically 5.0 meters, the potential energy gained by the second object will be what?

\[ U = mgh \]

If the second object has half the mass, it also has half the potential energy

So \[ 7.5 \text{ J} \]

9. An object with a speed of 25 meters per second has a kinetic energy of 400 joules. The mass of the object is what?

\[ K = \frac{1}{2} mv^2 \]

\[ m = \frac{2K}{v^2} = \frac{2(400)}{25^2} = 1.28 \text{ kg} \]

10. What happens to an object’s potential and kinetic energies as it approaches the ground?

\[ U_g \text{ decreases, } K \text{ increases} \]

11. As a pendulum moves from the bottom of its swing to the top of its swing what happens to the total mechanical energy, U and K?

Total - stays constant, \[ U_g \uparrow, K \downarrow \]

12. A 40 Newton force is required to hold a stretched spring 0.50 meters from its rest position. What is the potential energy stored in the stretched spring?

\[ F_s = kx \]

\[ k = \frac{F_s}{x} = \frac{40}{0.5} = 80 \text{ N/m} \]

\[ U_s = \frac{1}{2} kx^2 = \frac{1}{2} (80)(0.5)^2 = 10 \text{ J} \]

13. As the time required to do a given quantity of work decreases, the power developed \[ \text{ increases} \]
14. A constant force of 5.0 Newtons is used to push a 10.0-kilogram mass 7.0 meters across the floor. How much work is done on the mass?

\[ W = Fr = 5(7) = 35 \text{ J} \]

15. A person applies a constant 50 Newton force along the handle of a sled which makes a 47° angle with the horizontal. How much work is being done to the system by the person of the sled moves 10 m?

\[ W = Fr \cos \theta = 50(10) \cos(47) = 341 \text{ J} \]

16. Student A lifts a 70 Newton box from the floor to a height of 1.0 meter in 1.5 seconds. Student B lifts a 50 Newton box from the floor to a height of 1.0 meter in 1.0 second. Compared to student A, how much more, or less, work does student B produce?

Student A: \(70J\)

Student B: \(50J\)

17. Two blocks are dragged across the floor in the same direction. Block A has a mass of "m" and block B has a mass of 3"m." Block A has a velocity of 4"v" and block B has a velocity of "v." Compared to the kinetic energy of block A what is the kinetic energy of block B?

\[ A: \frac{1}{2} m(4v)^2 = 8mv^2 \]

\[ B: \frac{1}{2}(3m)v^2 = 1.5mv^2 \]

18. A 0.20-kilogram hail dropped vertically from a height of 7.00 meter above the floor bounces hack to a height of 2.80 meter. What is the mechanical energy lost by the ball as it bounces?

\[ \text{Energy lost} = \text{initial} - \text{final} = mgh - mgh_2 = mg(h_1 - h_2) = 0.2(9.8)[7 - 2.8] = 8.232 \text{ J} \]

19. If I were to fire a metal ball into the air with a spring launcher and found the ball's K = 20J and found that the spring was compressed 0.09m, what is the spring constant of the spring?

\[ K = \frac{1}{2} kx^2 \]

\[ 20J = \frac{1}{2} k(0.09)^2 \]

\[ k = 4938.3 \text{ N/m} \]

20. A 1.50 kg block is initially at rest. Then, it is pulled by a rope with constant tension of 20.0 N as shown below. The coefficient of kinetic friction, \(\mu_k\), between the block and the surface it slides upon is 0.350. Find the speed of the block after it has moved 5.00 m.

\[ W = \Delta K \]

\[ W_T - W_f = K_f - K_i \]

\[ F_T r - F_f r = \frac{1}{2} Mv^2 \]

\[ 20(5) - (35)(1.5)(9.8)(5) = \frac{1}{2}(1.5)v^2 \]

\[ v^2 = 99.03 \]

\[ v = 9.95 \text{ m/s} \]