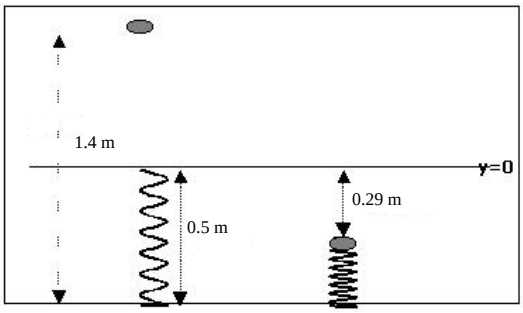
Physics

Unit 3: Work, Energy, and Momentum

1. *Meanings and concepts of terms like work, kinetic energy, gravitational potential energy, Conservation of mechanical energy, work-energy theorem, conservative force, nonconservative, elastic and inelastic collisions, impulse, momentum, isolated system, conserved*
2. *Know how force and time are related to collisions and impulse.*
3. *When is linear momentum and kinetic energy is conserved.*
4. *Mike is cutting the grass using a human-powered lawn mower. He pushes the mower with a force of 100 N directed at an angle of 20° below the horizontal direction. Calculate the work that Mike does on the mower in pushing it 5 m across the yard.*
5. *The kinetic energy of a car is 7000 J as it travels along a horizontal road. How much work is required to stop the car in 20 s?*
6. *A 15-kg block is lifted vertically 10 meters from the surface of the earth. To one significant figure, what is the change in the gravitational potential energy of the block?*
7. *An engineer is asked to design a playground slide such that the speed a child reaches at the bottom does not exceed 4.0 m/s. Determine the maximum height that the slide can be.*
8. *A ball of mass 5-kg is dropped from a height of 1.4 m (from the ground) onto a massless spring (the spring has an equilibrium length of 0.5 m). The ball compresses the spring by an amount of 0.29 m by the time it comes to a stop. Calculate the spring constant of the spring.*



9. *A warehouse worker uses a forklift to lift a crate of pickles on a platform to a height 5 m above the floor. The combined mass of the platform and the crate is 100 kg. If the power expended by the forklift is 2000 W, how long does it take to lift the crate?*
10. *Jennifer is walking at 0.5 m/s. If Jennifer weighs 980 N, what is the magnitude of her momentum?*
11. *A 10.0-kg steel ball is dropped straight down onto a hard horizontal floor and bounces straight up. Its speed just before and just after impact with the floor is 100 m/s. Determine the magnitude of the impulse delivered to the floor by the steel ball.*
12. *A 5000-kg cannon at rest contains a 100-kg cannon ball. When fired, the cannon ball leaves the cannon with a speed of 20 m/s. What is the recoil speed of the cannon?*
13. *A 2000-kg car traveling east at 50 m/s collides with a 500-kg car traveling west at 30 m/s. The cars stick together after the collision. What is their common velocity after the collision?*
14. *A driver slams on the brakes of a 900-kg car going at 40 m/s so that the wheels lock. The road is sloping upwards. If the car stops 20 m higher than it started, what is the work that friction did to stop the car?*

4. $F = 100\ N\ @20°, s = 5\ m$
$W = Fs\cos\theta = (100\ N)(5\ m)\cos 20° =$
$\mathbf{470\ J}$

5. $KE_0 = 7000\ J, t = 20\ s$
$W = KE_f - KE_0 = 0 - 7000\ J =$
$\mathbf{-7000\ J}$

6. $m = 15\ kg, h = 10\ m$
$PE = mgh = (15\ kg)\left(9.8\frac{m}{s^2}\right)(10\ m) =$
$\mathbf{1470\ J}$

7. $v_f = 4\frac{m}{s}$
$PE_f + KE_f = PE_0 + KE_0$
$\cancel{m}gh_f + \frac{1}{2}\cancel{m}v_f^2 = \cancel{m}gh_0 + \frac{1}{2}\cancel{m}v_0^2$
$\left(9.8\frac{m}{s^2}\right)(0\ m) + \frac{1}{2}\left(4\frac{m}{s}\right)^2 = \left(9.8\frac{m}{s^2}\right)h_0 +$
$\frac{1}{2}\left(0\frac{m}{s}\right)^2$
$8\frac{m^2}{s^2} = 9.8\frac{m}{s^2}\ h_0$
$h_0 = \mathbf{0.816\ m}$

8. $m = 5\ kg, h_0 = 1.4\ m, h_f = 0.5\ m -$
$0.29\ m = 0.21\ m, x = 0.29\ m$
$KE_0 + PE_0 = KE_f + PE_f$
$0 + mgh_0 = 0 + mgh_f + \frac{1}{2}kx^2$
$(5\ kg)\left(9.8\frac{m}{s^2}\right)(1.4\ m) =$
$(5\ kg)\left(9.8\frac{m}{s^2}\right)(0.21\ m) + \frac{1}{2}k(0.29\ m)^2$
$68.6\ J = 10.29\ J + (0.04205\ m^2)k$
$58.31\ J = (0.04205\ m^2)k$
$k = \mathbf{1387\ \frac{N}{m}}$

9. $h = 5\ m, m = 100\ kg, P = 2000\ W$
$P = \frac{W}{t} = \frac{Fs}{t} = \frac{mas}{t}$
$2000\ W = \frac{(100\ kg)\left(9.8\frac{m}{s^2}\right)(5\ m)}{t}$
$t = \mathbf{2.45\ s}$

10. $W = mg \rightarrow 980\ N = m\left(9.8\frac{m}{s^2}\right) \rightarrow m =$
$100\ kg$
$p = mv$
$p = (100\ kg)\left(0.5\frac{m}{s}\right) = \mathbf{50\ kg\frac{m}{s}}$

11. $m = 10\ kg, v_0 = -100\frac{m}{s}, v_f = 100\frac{m}{s}$
$J = F \cdot t = mv_f - mv_0$
$J =$
$(10\ kg)\left(100\frac{m}{s}\right) - (10\ kg)\left(-100\frac{m}{s}\right) =$
$\mathbf{2000\ Ns}$

12. $m_c = 5000\ kg, v_{0c} = 0, v_{fc} = ?$
$m_b = 100\ kg, v_{0b} = 0, v_{fb} = 20\frac{m}{s}$
$m_c v_{0c} + m_b v_{0b} = m_c v_{fc} + m_b v_{fb}$
$(5000\ kg)(0) + (100\ kg)(0) =$
$(5000\ kg)v_{fc} + (100\ kg)\left(20\frac{m}{s}\right)$
$0 = (5000\ kg)v_{fc} + 2000\ kg\frac{m}{s}$
$-2000\ kg\frac{m}{s} = (5000\ kg)v_{fc}$
$v_{fc} = \mathbf{-0.40\frac{m}{s}}$

13. $m_1 = 2000\ kg, v_{01} = 50\frac{m}{s}, v_{f1} = ?$
$m_2 = 500\ kg, v_{02} = -30\frac{m}{s}, v_{f2} = ?$
$m_1 v_{01} + m_2 v_{02} = m_1 v_{f1} + m_2 v_{f2}$
$(2000\ kg)\left(50\frac{m}{s}\right) + (500\ kg)\left(-30\frac{m}{s}\right) =$
$(2000\ kg)v_f + (500\ kg)v_f$
$85000\ kg\frac{m}{s} = 2500\ kg\ v_f$
$v_f = \mathbf{34\ m/s}$

14. $E_0 + W_{nc} = E_f$
$\frac{1}{2}mv_0^2 + W_{nc} = mgh_f$
$\frac{1}{2}(900\ kg)\left(40\frac{m}{s}\right)^2 + W_{nc}$
$= (900\ kg)\left(9.8\frac{m}{s^2}\right)(20\ m)$
$720000\ J + W_{nc} = 176400\ J$
$W_{nc} = -5.44 \times 10^5\ J$