2020 Sec 3 Physics Chapter 6 Work, Energy and Power

Answers to Examples and Exercises

6.1 Energy

Example 6.1.1
$E_k = ½(0.520)\ 5^2 =$ <u>6.5 J</u>

Example 6.1.2
$E_P = mgh = 30\ N \times 3.0\ m =$ <u>90 J</u>

6.2 Principle of Conservation of Energy

Example 6.2.1
(a) Types of energy: k.e., g.p.e.
Changes in energy/work: increase in k.e., decrease in g.p.e.

Word equation: increase in k.e. = decrease in g.p.e. OR gain in k.e. = loss in g.p.e

$½mv^2 - 0 = mgh$

$v^2 = 2gh$; v = <u>22 m s^{-1} (2sf)</u>

(b) Types of energy: k.e., g.p.e.
Changes in energy/work: decrease k.e., increase in g.p.e.

Word equation: increase in g.p.e = decrease in k.e. OR gain in g.p.e = loss in k.e.

$mgh = ½mv^2 - 0$

$h = ½ (15^2) \div 10 = 11.25\ m =$ <u>11 m (2sf)</u>

Exercises

6.1 Energy

1. Decrease in height = 3.0 sin 30° = 1.5 m; Loss in G.P.E. = (mg)h = 30x1.5 = 45 J

2. (a) <u>2</u> times. (b) <u>4</u> times.

3. $E_k = ½mv^2 = ½ (1.2) (0.25^2) = 0.0375\ J =$ <u>0.038 J (2sf)</u>

4. Change in $E_K = ½mv_1^2 - ½mv_2^2 = ½ (0.42) (20.0^2) - ½ (0.42) (5.0^2) = 84 - 5.25 = 79\ J$

6.2 Principle of Conservation of Energy

5. (a) K.E. = ½ mv^2 = ½ (0.200) $(12.0)^2$ = <u>14.4 J</u>

   (b) Initial K.E. of stone = 14.4 J; Initial G.P.E. of stone = 0 J
   Total = 14.4 J
   As stone travels upwards, K.E. of the stone is converted to G.P.E. of the stone. At the max height, K.E. of the stone = 0 J
   G.P.E. gained = mgh = (0.200)(10)(5.2) = 10.4 J
   Total = 10.4 J
   Decrease in energy = Loss in energy while travelling through air
   = 14.4 J – 10.4 J = <u>4.0 J</u>

6. No. The car accelerates, therefore kinetic energy increases. The car goes up a hill, therefore, potential energy increases. KE and PE both increases and thus, they are not conserved. This energy is converted from the chemical energy of the fuel in the car.

6.3 Work

Example 6.3.1
1. (a) Work done = 20 J (b) Work done = 0 J (c) Work done = (10 cos 30°) (2.0) = 17 J

2. Work done = F x d = 50 N x 0.40 m = <u>20 J</u>

3. Minimum work done = energy converted to g.p.e = mgh = 3.2 x 10 x 5.0 = <u>160 J</u>

Exercises

1 (a) Yes, work done by shopper on the trolley. Work is done through the pushing force exerted by the shopper on the trolley through a horizontal distance. This work is done against frictional force on the trolley.
(b) Yes, work done by gravity on the boy. Work is done through the weight of the boy, exerted by Earth on the boy, through a distance down the slope. The work done converts gravitational potential energy to kinetic energy of the boy.
(c) No, the pillar did not move.
(d) Yes, work done by gravity on the marble. Work is done through the weight of the marble, exerted by Earth on the marble through a vertical distance. The work done converts gravitational potential energy to kinetic energy of the marble.

2. Work done = 50 N x 2.5 m = 125 J = 130 J (2 sf)

3. Increase in K.E. of man = 0J (constant speed)
   Increase in G.P.E. of man = (60)(10)(80 sin30°) = 24 000 J
   Work done by man = Increase in G.P.E. = 24 000 J

   The energy is converted from stored (chemical) energy to G.P.E.

4. (a) WD = 8 x 8 = 64 J; Gain in energy of block = 64 J.
   (b) The work done is converted to kinetic energy.

5. (a) (i) WD by pulling force = 1800 N x 50.0 m = 90 000 J = 90.0 kJ
   (ii) WD against friction = 1000 N x 50.0 m = 50 000 J = 50.0 kJ
   (iii) WD against gravity = 5000 N x 3.0 m = 15 000 J
   (iv) P.E. gained by block = WD against gravity = 15 000 J

   (b) (i) Use your answers in (a) above to complete the table below.

	Initial Energy / J	**Work / J**	**Final Energy / J**
	G.P.E.= 0 J K.E. = 0 J	By pulling force = 90.0 kJ Against friction = 50.0 kJ	G.P.E.= 15.0 kJ K.E. = 40.0 – 15.0 = 25.0 kJ
Total	**0 J**	**90.0 – 50.0 = 40.0 kJ**	**40.0 kJ**

   (ii) WD done by pulling force - WD against friction
   = Gain in mechanical energy (G.P.E. and/or K.E.) of the object.

   The total gain in mechanical energy of the object is 40 kJ, of which 15 kJ is the gain in gravitational potential energy. Therefore, there is an excess of 25 kJ, which must be the gain in KE of the object.

6.4 Power

Example 6.4.1

$$\text{Power} = \frac{\text{Work done}}{\text{Time taken}} = \frac{500\text{x}10\text{x}10}{25} = 2000\text{W}$$

Exercises

1. Time = work done / Power = (1000 × 10 × 20) / 25000 = 8.0 s

2. Gain in KE = ½ (60) $(7.6)^2$ = 1732.8 J
   Useful Power developed = 1732.8 / 0.9 = 1925.33 = 1930 W (3 s.f.)

3. (a) Lowest KE = ½mv^2 = ½(1500) 11000^2 = 9.1×10^{10} J

   (b) Average power = gain in KE ÷ t = $9.1 \times 10^{10} \div 10(60)$ = 1.5×10^8 W

6.5 Efficiency

Example 6.5.1

Output power = $\frac{\text{Work done}}{\text{Time taken}} = \frac{Fxd}{t}$ = F v = mgv = 1000 x 10 x 1.5 = 15 kW

Efficiency = $\frac{\text{output power}}{\text{input power}}$ x100% = $\frac{15}{20}$ x100%= 75%

Exercises

1. Efficiency = 3840 /4500 × 100% = 85 % (2 s.f.)

2. Efficiency = 70% = output power /input power x 100%
   Input power = (550 × 0.20)/70 × 100 = 157 W = 160 W (2 s.f.)