Physics worksheet solutions – Work, energy and power (g = 9.8 N kg^{-1})

Q1 A 75-kg person pushes a 30-kg box with a force of 120 N along a horizontal floor for 3 metres. The force of friction between the box and the floor is 20 N. (i) Calculate the work done by the person. (ii) Calculate the work done against friction. (iii) Calculate work done on the box by the net force. (iv) Calculate the change in kinetic energy of the box.

(i) $W_{push} = Fs = 120\times 3 = 360$ J (ii) $W_{friction} = 20\times 3 = 60$ J

(iii) $W_{net.force} = (120-20)\times 3 = 300$ J (iv) $\Delta E_k = W_{net.force} = 300$ J

Q2 The force of air resistance F N on a 0.10-kg marble dropped from a great height is shown in the following graph where x m is the distance fallen. (i) Calculate the work done by gravity on the marble after the first 5 metres of the fall. (ii) Calculate the work done by air resistance in the 5-m fall. (iii) Calculate the speed of the marble after falling the first 5 m.

(i) $W_{gravity} = Fs = mgs = 0.10\times 9.8\times 5 = 4.9$ J

(ii) $W_{resist} = area.under.graph = \frac{1}{2}\times 5\times 0.8 = 2.0$ J

(iii) $\Delta E_k = W_{gravity} - W_{resist} = 4.9 - 2.0 = 2.9$ J

$\frac{1}{2}mv^2 = 2.9$, $v = \sqrt{\frac{2\times 2.9}{0.10}} \approx 7.6$ ms^{-1}

Q3 A 75-kg parcel is tied to a 10-m bungee cord which is fastened to a bridge. The cord has a force constant of 149.3 Nm^{-1}. The parcel falls a vertical distance of 26 m to a stop when it is dropped from the bridge. (i) Calculate the change in gravitational potential energy of the parcel. (ii) Calculate the elastic potential energy in the bungee cord when the parcel is at its lowest point. (iii) Determine the maximum kinetic energy of the parcel during the fall.

(i) $\Delta E_{gp} = mgh = 75\times 9.8\times 26 = 1.91\times 10^4$ J

(ii) $E_{ep} = \frac{1}{2}kx^2 = \frac{1}{2}\times 149.3\times (26-10)^2 = 1.91\times 10^4$ J ,

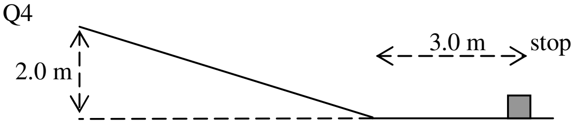
or $E_{ep} = \Delta E_{gp} = 1.91\times 10^4$ J

(iii) Max. kinetic energy occurs when the net force on the parcel is zero.
$mg = kx$, $75\times 9.8 = 149.3x$, $x \approx 4.92$.
Total energy is constant,

.: $75\times 9.8\times (26-10-4.92) + E_k + \frac{1}{2}\times 149.3\times 4.92^2 = 1.91\times 10^4$

$E_k \approx 9.1\times 10^3$ J

Q4



A 2.0-kg object slides down a slope from a height of 2.0 m. It starts from rest and comes to a stop on the horizontal plane after travelling 8.0 m in total. (i) Determine the amount of heat generated due to friction. (ii) Determine the average force of friction against the motion of the object. (iii) Assuming a constant force of friction throughout the motion, determine the maximum kinetic energy of the object.

(i) Heat generated = gravitational potential energy
$= mgh = 2.0\times 9.8\times 2.0 = 39.2$ J

(ii) Work done by $F_{friction} = F_{friction,av}\times d = F_{friction,av}\times 8.0 = 39.2$

$F_{friction,av} = 4.9$ N

(iii) Maximum $E_k = 4.9\times 3.0 = 14.7$ J

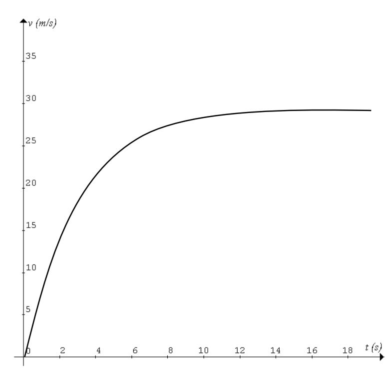
Q5 A 25-kg mass placed at the centre of a trampoline causes it to depress by 7.5 cm, whilst a 50-kg mass depresses the trampoline by 15 cm.
(i) Calculate the increase in elastic potential energy of the trampoline when the 25-kg mass is replaced by the 50-kg mass.
(ii) Calculate the maximum depression if the 50-kg mass is dropped from a height of 1.0 m above the centre of the trampoline.

(i) The depression is doubled when the depressing force is doubled, .: it appears that the trampoline is elastic and follows Hook's law. The force-depression graph is linear through the origin. Area under the graph gives the change in elastic potential energy. $\Delta E_{ep} = \frac{1}{2}(25\times 9.8 + 50\times 9.8)(0.15-0.075) \approx 27.6$ J

(ii) $k = \frac{F}{x} = \frac{50\times 9.8}{0.15}$ Nm^{-1}, $E_{ep} = \Delta E_{gp}$, $\frac{1}{2}kx^2 = mg(1+x)$,

$\frac{1}{2}\times \frac{50\times 9.8}{0.15}\times x^2 = 50\times 9.8\times (1+x)$, $x \approx 0.72$ m

Q6 The velocity-time graph of a 1000-kg car with a constant driving force of 3000 N is shown below. (i) Estimate the power of the car at $t = 6$ s. (ii) Estimate the average power of the car in the first 12 s.



(i) $P = Fv \approx 3000\times 26 = 7.8\times 10^4$ W

(ii) $v_{av} \approx 21$ ms^{-1} estimated from the graph,

$P_{av} = Fv_{av} \approx 3000\times 21 = 6.3\times 10^4$ W