Chapter 9 Work and Energy

1.(a) Work = Force × Dist.
$= 25\,N \times 3.5\,m$
$= 87.5\ Nm = \underline{87.5\ J}$

(b) Work $= F \times s = m \times g \times s$
$= 20\,kg \times 10\ ms^{-2} \times 0.85\,m$
$= 170\ kg\,m^2 s^{-2} = \underline{170\ J}$

(c) Work $= m \times g \times s = 200 \times 10 \times 25$
$= \underline{50\ 000\ J}$

2.(a) Work $= m \times g \times s$
$= 200\,kg \times 10\,m/s^2 \times 9\,m$
$= \underline{18\ 000\ J}$

(b) Work is done by the piano.
Gravitational potential energy stored is released as heat as it moves downwards.

3 (a) Work done is equivalent to the area under the graph:
For horse A, Work $= 70\,N \times 120\,m$
$= \underline{84\ 000\ J}$
For horse B, Work $= 50\,N \times 120\,m$
$= \underline{6\ 000\ J}$

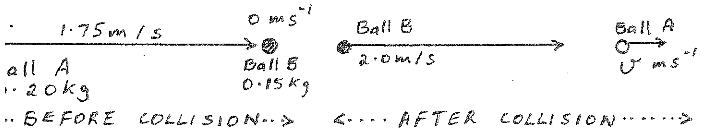
(b) Total work = Work of A + Work of B
$= \underline{14\ 00\ J}$

4 (a) Work = area under the curve $= \frac{1}{2}$ base × height
$= \frac{1}{2} \times 20\ m \times 40\,N$
$= \underline{400\ J}$

(b) Each square is $100N \times 50\,m$ ($= 5000\ J$)
$\therefore$ Total area $= 8 \times 5000 = \underline{40000\ J}$

(c) Each square is $1\ N \times 20\,m$ ($= 20\ J$)
$\therefore$ Total area $= 14$ squares $\times 20\ J$
$= \underline{280\ \text{Joules}}$

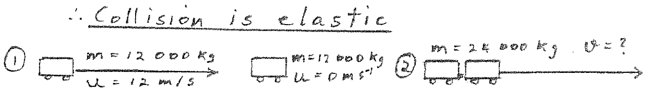
5. For linear elastic collisions between objects of equal mass, the objects SWAP VELOCITIES. In the case here, this 'pool players result' will ensure ball A stops and ball B moves off at $5\ ms^{-1}$.



) Initial momentum = Final momentum
$0.20 \times 1.75 + 0.15 \times 0 = 0.15 \times 2.0 + 0.20 \times \upsilon$
$\therefore\ \upsilon = \frac{0.2 \times 1.75 + 0 - 0.15 \times 2.0}{0.20}$
$= \underline{0.25\ ms^{-1}}$

) If the collision is elastic E_K initial $= E_K$ final
E_k initial $= \frac{1}{2} m_1 u_1^2 + \frac{1}{2} m_2 u_2^2$
$= \frac{1}{2} \times 0.20 \times (1.75)^2 + \frac{1}{2} \times 0.15 \times 0^2$
$= 0.30625\ J$
E_k final $= \frac{1}{2} m_1 \upsilon_1^2 + \frac{1}{2} m_2 \upsilon_2^2$
$= \frac{1}{2} \times 0.20 \times (0.25)^2 + \frac{1}{2} \times 0.15 \times (2.0)^2$
$= 0.30625\ J$

$\therefore$ Collision is elastic



) Initial momentum = Final momentum
$\therefore\ 12\ 000 \times 12 + 12\ 000 \times 0 = 24\ 000 \times \upsilon$
$\therefore\ \upsilon = \frac{12\ 000 \times 12 + 0}{24000} = \underline{6\ ms^{-1}}$

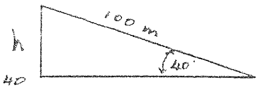
) E_k (initial) $= \frac{1}{2} \times 12\ 000 \times 12^2 = 864\ 000\ J$
E_k (final) $= \frac{1}{2} \times 24\ 000 \times 6^2 = 432\ 000\ J$
Lost E_k (INELASTIC COLLISION) $= 864\ kJ - 432\ kJ = \underline{432\ 000\ J}$

8.(a) GPE $= mgh = 2.5\,kg \times 10\ ms^{-2} \times 2.5\,m$
$= \underline{62.5\ J}$

(b) The brickie does work of $\underline{62.5\ J}$

9. $h = \frac{GPE}{mg} = \frac{1000\ kg\,m^2 s^{-2}}{30\ kg \times 10\ ms^{-2}}$
$= \underline{3.3\ m}$

10.
$h = 100 \sin 40$
GPE $= mgh$
$= 75 \times 10 \times 100 \sin 40$
$= \underline{48\ 200\ J}$



11. $P = 2000 \times 1.5\ kw$
$= 3000\ kw$

12.(a) $P = \frac{work}{time} = \frac{mgh}{t} = \frac{100 \times 10 \times 1.2}{2} = \underline{600w}$

(b) $P = \frac{work}{time} = \frac{mgh}{t} = \frac{2700 \times 10 \times 1.9}{15} = \underline{3420W}$

13(a) $E_{k(init)} = \frac{1}{2} m\upsilon^2 = \frac{1}{2} \times 2200 \times 10^2 = \underline{1.1 \times 10^5\ J}$
$E_{k(final)} = \frac{1}{2} m\upsilon^2 = \frac{1}{2} \times 2200 \times 15^2 = \underline{2.5 \times 10^5\ J}$

(b) Work $= \Delta E_k = (2.5 - 1.1) \times 10^5\ J$
$= \underline{1.4 \times 10^5\ J}$

(c) Power $= \frac{work}{time} = \frac{1.4 \times 10^5}{20}$
$= \underline{7.0\ Kw}$

14. Power $= \frac{work}{time} = \frac{F \times s}{t} = F \times \upsilon$ (since $\upsilon = \frac{s}{t}$)
$\therefore\ F = \frac{Power}{\upsilon} = \frac{2.5 \times 10^6\ w}{14\ ms^{-1}}$
$= \underline{1.8 \times 10^5\ N}$

15. Work = Force × distance
$= \underbrace{550 \times 0.4536 \times 9.81}_{\text{Force}} \times \underbrace{0.3048}_{\text{dist.}}$
$= \underline{746\ \text{Watts}}$

16. GPE $= E_K$ (as diver falls GPE $\rightarrow E_K$)
$\therefore\ \cancel{m} g h = \frac{1}{2} \cancel{m} \upsilon^2$
$\therefore\ gh = \frac{1}{2} \upsilon^2$
$\therefore\ \upsilon = \sqrt{2gh} = \sqrt{2 \times 10 \times 8.5}$
$= \underline{13\ m\,s^{-1}}$

17.(a) Work $= mgh$
$= 266 \times 10 \times 2.4$
$= 6384 \approx \underline{6400\ J}$

(b) GPE = (as wt. drops GPE $\rightarrow E_K$)
$\therefore\ mgh = \frac{1}{2} m\upsilon^2$
$\therefore\ \upsilon = \sqrt{2gh} = \sqrt{2 \times 10 \times 2.4} = \sqrt{48}$
$= \underline{6.9\ m\,s^{-1}}$

18. $u = \frac{m + M}{m} \sqrt{2gh}$
$= \frac{0.00041 + 0.1123}{0.00041} \sqrt{2 \times 10 \times 0.015}$
$= 275 \times 5.4 \times 10^{-1}$
$= 148\ ms^{-1}$
$\approx \underline{150\ ms^{-1}}$

19. $EPE = \frac{1}{2} k x^2$

$= \frac{1}{2} \times 265 \times (0.34)^2 \ \frac{N\ m^2}{m}$

$= \underline{15\ J}$

20. (a) Work = area under graph

$= \frac{1}{2} \times 40 N \times 0.20 m$

$= \underline{4\ J}$

(b) spring const. $= K$ = slope of line

$= \frac{\Delta y}{\Delta x} = \frac{40\ N - 0}{0.20 m - 0}$

$= \underline{200\ N\ m^{-1}}$

(c) $EPE = \frac{1}{2} k x^2$

$= \frac{1}{2} \times 200 \times (0.17)^2$

$= \underline{2.9\ J}$

21. $E_k = EPE$

(locomotive) (spring bumper)

$\frac{1}{2} m v^2 = \frac{1}{2} k x^2$

$\therefore \ m v^2 = k x^2$

$\therefore \ x = \sqrt{\frac{m v^2}{K}}$ $\left(v = \frac{5 km}{hr} = \frac{5000}{3600} = 1.39\ m s^{-1} \right.$

$= \sqrt{\frac{336000 kg \times (1.39^2)\ m^2 s^{-2}}{4 \times 10^8\ N\ m^{-1}}}$

$= \underline{4 \times 10^{-2}\ m}$

22. (a) Efficiency $= \frac{18}{60} \times 100$

$= 30\%$

(b) The remaining 42 J heats the glass of the bulb, the gas in the bulb.

23. Work $= F \times s \cos\theta$

$= 90 \times 10 \cos 35°$

$= 740\ J$

24.

Work = area under the graph

$= (\frac{1}{2} \times 8 \times 4) + (8 \times 2) + (\frac{1}{2} \times 8 \times 4)$

$= 16 + 16 + 16 = \underline{48\ J}$

25. $K.E. = \frac{1}{2} m v^2 = \frac{1}{2} \times 0.060 \times (8)^2$

$= \underline{1.92\ J}$

26. $P = \frac{W}{t} \quad \therefore \quad W = P \times t$

$= 2000 W \times 105 s$

$= \underline{2.1 \times 10^5\ J}$

27. $KE_i = \frac{1}{2} m_A u_A^2 + \frac{1}{2} m_B u_B^2$

$= \frac{1}{2} \times 10 (4)^2 + \frac{1}{2} \times 3 \times (0)^2$

$= 80\ J$

$KE_f = \frac{1}{2} m_A v_A^2 + \frac{1}{2} m_B v_B^2$

$= \frac{1}{2} \times 13 \times (3)^2$

$= 58.5\ J$

$\therefore$ collision is not elastic

28. $G.P.E. = mgh = 50 \times 10 \times 1.4$

$= \underline{700\ J}$

29. $P = \frac{W}{t} = \frac{F \times s}{t} = \frac{65 \times 10 \times 12}{14}$

$= \underline{560\ W}$

30. when rock is released:

$KE = 0 \quad GPE = m \times g h = 2 kg \times 10 \times 8.5$

$= 170\ J$

At impact:

$KE = 170\ J \quad GPE = 0$

$\therefore \frac{1}{2} m v^2 = 170\ J$

$\therefore v^2 = 170 \times \frac{2}{m} = 170 \times \frac{2}{2}$

$v = \sqrt{170} = \underline{13\ m s^{-1}}$

31. $EPE = \frac{1}{2} k x^2$

$= \frac{1}{2} \times 150 \times (0.25)^2$

$= \underline{4.7\ J}$

32.
(b) K(from graph) $= \frac{\Delta y}{\Delta x} = \frac{0.4 \times 10}{0.18} = \underline{22\ N m^{-1}}$

(a) Work = area under the curve

$= \frac{1}{2} \times 0.4 kg \times 10 \times 0.18$

$= \underline{0.36\ J}$

(c) (i) $EPE = \frac{1}{2} k x^2 = \frac{1}{2} \times 22 \times (0.1)^2$

$= \underline{0.11\ J}$

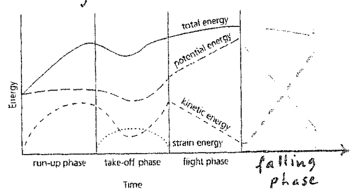
(ii) $EPE = \frac{1}{2} k x^2 = \frac{1}{2} \times 22 \times (0.2)^2$

$= \underline{0.44\ J}$

33. (a) run up: 1, take-off: 2, flight 3–6

(b) work is done by the athlete: she speeds up and KE increases

(c) GPE is to the centre of mass, which is above ground level



(e) No it would be lower, because her centre of gravity is lower when she lands on the mat.

34.
a) Assume conservation of momentum

$\therefore m_1 u_1 + m_2 u_2 = m_1 v_1 + m_2 v_2$

$\therefore 1.6 \times 5.5 + 2.4 \times 2.5 = 1.6 v_1 + 2.4 \times 4.9$

$14.8 = 1.6 v + 11.8$

$\therefore v_1 = \frac{14.8 - 11.8}{1.6}$

$= \underline{1.9\ m s^{-1}}$

Q 34 continued on next page.