1

(a)

$$E = \frac{1}{2}kx^2$$
$$E = \frac{1}{2}(29)(8.0 \times 10^{-2})^2$$
$$E = 9.3 \times 10^{-2}\ J$$

(b) $\Delta GPE = mg(\Delta \mathrm{h})$
$= 4.5 \times 10^{-2} \times 9.81 \times 8.0 \times 10^{-2} \sin 15°$
$= 9.1 \times 10^{-3}\ J$

By Conservation of Energy
$loss\ in\ EPE = gain\ in\ KE + gain\ in\ GPE$
$(9.3 \times 10^{-2} - 9.1 \times 10^{-3}) = \frac{1}{2}(4.5 \times 10^{-2})v^2$
$v = 1.9\ m\ s^{-1}$

(c) The speed will be lower as the spring will possess some KE (or GPE).2

2

(a) **(i)**

$$u_y = u \sin\theta$$
$$= 25 \sin 30°$$
$$= 12.5\ m\ s^{-1}$$

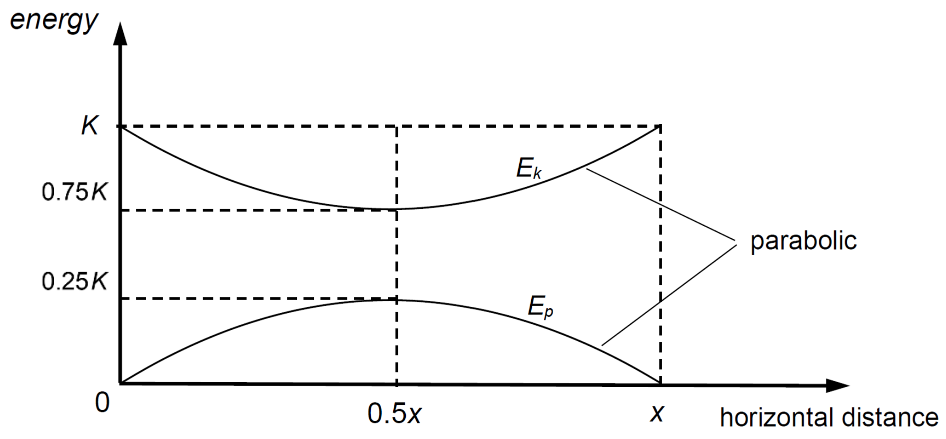
(ii)

$$v_y^2 = u_y^2 + 2a_y s_y$$
$$0 = 12.5^2 + 2(-9.81)s_y$$
$$s_y = 7.96\ m$$

(iii)

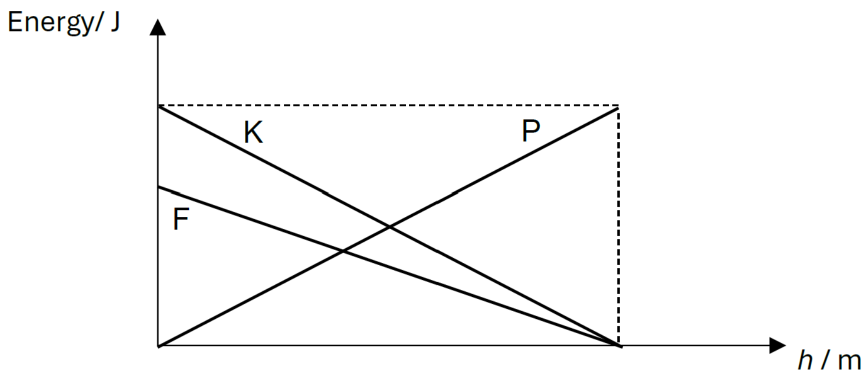
$$KE_i = \frac{1}{2}mu^2$$
$$v_x = u \cos 30°$$
$$KE\ at\ 8.0\ m = \frac{1}{2}m(u\cos 30°)^2 = 0.75K$$
$$PE\ at\ 8.0\ m = K - 0.75K = 0.25K$$

(b) **(i), (ii)**



3

(a)



(b) Some potential energy lost will be converted to do work against friction, hence the gain in kinetic energy will be less as compared to the situation without friction.

4

(a) By conservation of energy,

$loss\ in\ GPE = gain\ in\ EPE$

$mgh = \frac{1}{2}kx^2$

$m = \frac{kx^2}{2gh} = 0.0290\ kg$

(b) When the spring first compresses, the magnitude of the force from the spring is less than weight. Hence, there is still a downward resultant force that causes the marble to continue accelerating.

(c) Max speed of marble happens when force from spring = weight

$kx = mg$

$x = \frac{mg}{k} = 0.01136$

$gain\ in\ EPE = \frac{1}{2}kx^2 = 0.001614\ J$

$loss\ in\ GPE = mg(0.060 + 0.01136) = 0.02027\ J$

$gain\ in\ KE = loss\ in\ GPE - gain\ in\ EPE$

$= 0.019\ J$

5

(a) Work done is the product of the force and the displacement moved in the direction of the force

(b) **(i)** $\Delta s = Area\ under\ v - t\ graph$

$= \frac{1}{2}(1.0 + 4.0)(2.4)$

$= 6.0\ m$

(ii) $Increase\ in\ GPE\ = mg\Delta h$

$= 13000 \times 6.0$

$= 7.8 \times 10^4\ J$

$Increase\ in\ KE\ = \frac{1}{2}m\Delta v^2$

$= \frac{1}{2}\left(\frac{1300}{9.81}\right)(2.4^2)$

$= 3817\ J$

$Work\ done\ against\ friction\ =\ F\ \times\ s$
$=\ 2000\ \times\ 6.0$
$=\ 1.2\ \times\ 10^4$
$Work\ done\ by\ motor$
$=\ Increase\ in\ energy\ of\ the\ lift\ +\ Work\ done\ against\ friction$
$=\ \Delta GPE\ +\ \Delta KE\ +\ W$
$=\ 78000\ +\ 3817\ +\ 12000$
$=\ 9.38\ \times\ 10^4\ J$

(iii) $Output\ power\ =\ F\ v$
$=\ 1.6\ \times\ 10^4\ \times\ 2.0$
$=\ 3.2\ \times\ 10^4\ W$

$$\eta = \frac{P_o}{P_i}$$

$$= 0.67 = \frac{3.2 \times 10^4}{P_i}$$

$Input\ Power\ =\ 4.78\ \times\ 10^4\ W$

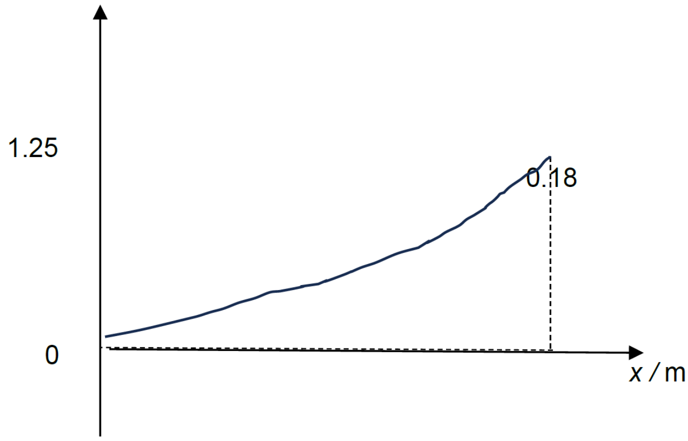
6

(b) **(i)** $change\ in\ KE = Net\ work\ done$

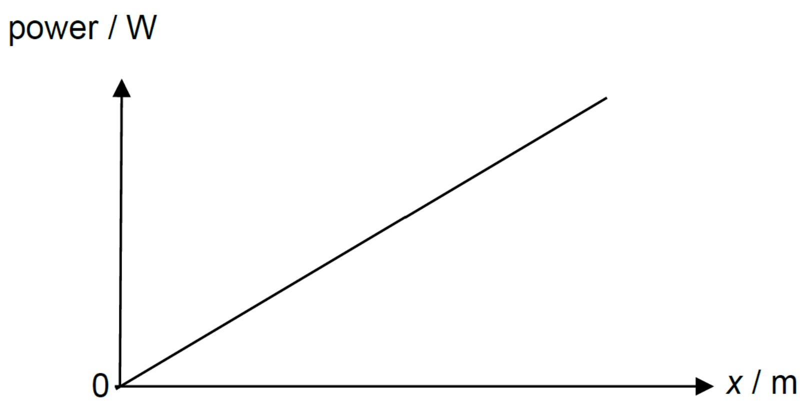
$$-\frac{1}{2}mu^2 = -\frac{1}{2}F_{max}x$$

$x = 0.18\ m$

(ii)



(iii)



7

(a) $\Delta E_p = mgh$
$= 1.5(9.81)(-510)$
$= -7500\,J$

(b) speed = gradient of tangent to the graph at $t = 16\,s$
$= 50\,m\,s^{-1}$ (acceptable range: $49\,m\,s^{-1}$ to $52\,m\,s^{-1}$)

(c) $\Delta E_k = \frac{1}{2}mv^2 - \frac{1}{2}mu^2$
$= \frac{1}{2}(1.5)(50)^2 - 0$
$= 1880\,J$

(d) Work is done by object to overcome drag force.

(e) By conservation of energy
Work done against resistive force = Loss of E_k and E_P
$F(0.85) = 1880 + (1.5 \times 9.81 \times 0.85)$
$F = 2210\,N$

8

(a)

	gravitational potential energy / kJ	elastic potential energy / kJ	kinetic energy / kJ
top	23.5	0	0
half-way	11.8	2.6	9.17
bottom	0	23.5	0

(b) Let the spring constant of the elastic rope be k and unstretched length be x
At half-way position, $2.6 = \frac{1}{2}k(20 - x)^2$
At bottom position, $23.5 = \frac{1}{2}k(40 - x)^2$
$\frac{2.6}{23.5} = \frac{(20 - x)^2}{(40 - x)^2}$
$x = 10\,m$

(c) $mg = ke$ where e is the extension when her speed is the highest
$\frac{1}{2}kx^2 = \frac{1}{2}k(30)^2 = 23500$
$k = 52.2$
$e = \frac{60 \times 9.81}{52.5} = 11.3\,m$

9

(a) The resultant force acting on a body is the rate of change of momentum of the body and acts in the direction of the change in momentum.

(b) Work W is the product of a force F and a displacement s in the direction of the force.
Since Power P is the rate of doing work,
Hence, $P = W/t$
$= Fs/t$
$= Fv$

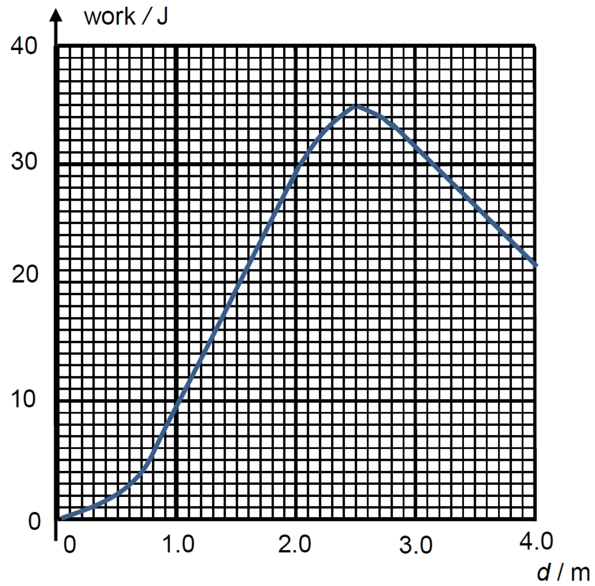
(c) **(i)** At constant speed, no net force acting on lorry.
Hence, magnitude of driving force is equal to that of resistive force on lorry.
Driving force, $F = P/v$
$= 130\,000/25$
$= 5200\ N$

(ii) Friction between tyres of lorry and road exerts a backward force on the road.
By Newton's third law, road surface exert a forward force of equal magnitude on tyres.

(d) $F - mg\sin\theta - R = ma$
$F = 36000(9.81\sin 1.4°) + 5200 + (36000)(0.15)$
$= 19228\ N = 19000\ (19200)\ N$

10

(a)



(b) **(i)** Gain in GPE $= mgh = mgd\sin 30°$
$= (0.50)(9.81)(2.0)\sin 30°$
$= 4.9\ J$

(ii) Gain in KE = WD on mass – WD against friction – gain in GPE
$= 30 - (3.0)(2.0) - 4.9$
$= 19.1\ J$