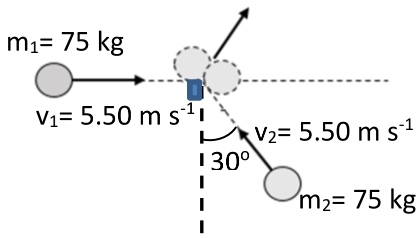
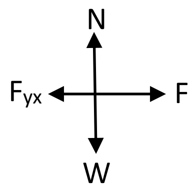
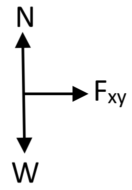
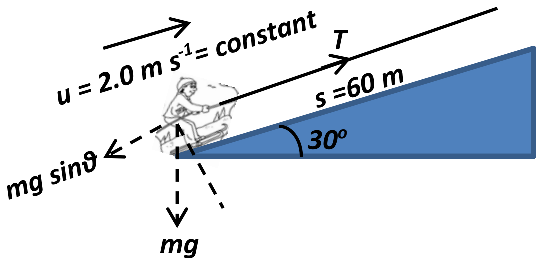
PSPM 1 MODEL PHYSICS PAPER ANSWER SCHEME
SF015

No.	Solution	Marks
1	$X = \frac{1}{2}\rho v^2$ $[X] = \left[\frac{1}{2}\right][\rho][v^2]$ $= (1)\left[\frac{m}{V}\right][v]^2$ $= (ML^{-3})(LT^{-1})^2$ $= ML^{-3}L^2T^{-2}$ $= ML^{-1}T^{-2}$	**G1** **J1**
2	(a)(i) Given u = 0 m s^{-1}, a = 2 m s^{-2}, t = 5 s, v =? Using v = u + at v = 0 + (2)(5) = 10 m s^{-1} (ii) Using $a_{ave} = \frac{\Delta v}{\Delta t} = \frac{v_f - v_i}{t_f - t_i}$ $= \frac{10-0}{15-0}$ $= 0.67\ m s^{-2}$	**GJU1** **G1** **JU1**
	(b) No. Given u = 16 m s^{-1}, v = 0 m s^{-1}, a = - 3.5 m s^{-2}, s'=? Using $v^2 = u^2 + 2as$ $0 = 16^2 + 2(-3.5)s'$ $s' = 36.57\ m\ (> 36\ \text{m})$ $\Delta s = s' - s$ $= 36.57 - 36 = 0.57\ m$ The car does not manage to avoid the collision as it crashes into the lorry and moves for 0.57 m before it stops.	**J1** **G1** **K1** **GJU1**
	(c) The ball is thrown **horizontally => u_y = 0 m s^{-1}** The initial velocity, u = 16.0 m s^{-1} = u_x The vertical component of the velocity of the ball when it hits the ground,	**K1**

	$\theta = \tan^{-1}(\frac{v_y}{v_x})$	
	$60.0^o = \tan^{-1}(\frac{v_y}{16.0})$	**G1**
	$v_y = 27.7\ m\,s^{-1}$	
	$(downward)$	
	Then using	
	$v_y^2 = u_y^2 - 2gs_y$	
	$(-27.7)^2 = 0 - 2(9.81)H$	
	$H = -39.1\,m$	**GJU1**
	Therefore, the height of the building is 39.1 m.	
3	(a) Given m = 10.0 x 10^{-3} kg, u = 0 m s^{-1}, v = 4.43 m s^{-1}, Δt = 0.02 s Using impulse-momentum theorem	
	$m(v-u) = F\Delta t$	**K1**
	$(10.0\times10^{-3})(-4.43-0) = \mathrm{F}(0.02)$	**G1**
	$\mathrm{F} = -2.215\ \mathrm{N}$	**JU1**
	(downward)	
	(b)  	
	$\sum P_{ix} = \sum P_{fx}$	
	$m_1u_{1x} + m_2u_{2x} = (m_1 + m_2)v_x$	
	$75(5.50) + 75(-5.50\sin 30^o) = (75+75)v_x$	**KG1**
	$v_x = 1.375\ m\ s^{-1}$	
	$\sum P_{iy} = \sum P_{fy}$	
	$m_1u_{1y} + m_2u_{2y} = (m_1 + m_2)v_y$	
	$0 + 75(5.50\cos 30^o) = (75+75)v_y$	**KG1**
	$v_y = 2.38\ m\ s^{-1}$	
	Therefore, the magnitude of velocity after the collision is	
	$v = \sqrt{(v_x)^2 + (v_y)^2}$	
	$= \sqrt{(1.375)^2 + (2.38)^2}$	**KG1**
	$= 2.75\ m\ s^{-1}$	**JU1**

	(c) (i) Free body diagram for	
	X: 	
	Y: 	D2
	All 7 forces with label and direction correct: 2 marks One wrong: 1 mark More than one wrong: 0 mark	
	(ii) $\sum F = ma$	
	$F = (m_x + m_Y)a$	K1
	$35 = (30+40)\times 10^{-3} a$	
	$a = 500\ m\ s^{-2}$	GJU1
	(iii) Apply ΣF = ma on block Y	
	$F_{xy} = m_y a$	K1
	$= (40\times 10)^{-3}(500)$	
	$= 20.0\ N$	GJU1
4	(a) $\sum E_i = \sum E_f$	
	$U_{si} = U_{sf} + K_f$	
	$\frac{1}{2}kx_i^2 = \frac{1}{2}kx_f^2 + \frac{1}{2}mv^2$	K1
	$2000(0.100)^2 = 2000(0.050)^2 + 2.0v^2$	G1
	$v = 2.74\ m\ s^{-1}$	JU1
	(b) 	
	(i) Since the skier is pulled up at constant speed, *ΣF = 0*.	K1
	$T = mg\sin\theta$	
	$W_{pull} = Ts\cos\theta$	
	$= (mg\sin\theta)s\cos 0^o$	
	$= (mg\sin\theta)s$	
	$= (70)(9.81)\sin 30^o(60)$	G1
	$= 20.6\,kJ$	JU1
	Options: *Using work energy theorem* $W = \Delta K$ $(T - mg\sin\theta)s\cos 0^o = 0$ $Ts - (mg\sin\theta)s = 0$ $Ts = (70)(9.81)(60)\sin 30^o$ $W_{pull} = 20.6\,kJ$	

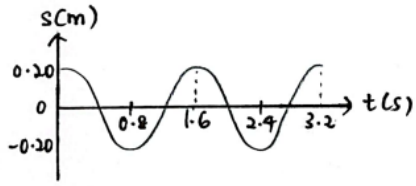
	(ii) $$P_{motor} = Fv\cos\theta = Tv\cos 0^o = (mg\sin\theta)v = (70)(9.81)\sin 30^o(2.0) = 686.7W$$ ***Options:*** $t = \frac{s}{v} = \frac{60}{2.0} = 30\,s$ $P_{motor} = \frac{W_{motor}}{t} = \frac{20.6\times10^3}{30} = 686W$	**G1** **JU1**
5	(a) At the lowest point, using $F_C = \frac{mv^2}{r}$ $T - mg = \frac{mv^2}{l}$ $T = \frac{mv^2}{l} + mg$	**K1** **J1**
	(b) x = 0.65 – 0.50 = 0.15 m $F_C = \frac{mv^2}{r}$ $T = \frac{m(r\omega)^2}{r}$ $kx = mr\omega^2$ $40(0.15) = (0.020)(0.65)\omega^2$ $\omega = 21.5\,rad\,s^{-1}$	**K1** **K1** **GJU1**
6	(a) Given m = 0.50 kg, A = 0.20 m, T = 1.6 s (i) For spring-mass system, the period $T = 2\pi\sqrt{\frac{m}{k}}$ $T^2 = 4\pi^2(\frac{m}{k})$ $(1.6)^2 = 4\pi^2(\frac{0.50}{k})$ $k = 7.71\,N\,m^{-1}$ (ii) When y = 0 m, v =? Using $v = \omega\sqrt{A^2 - y^2}$ *and* $\omega = \frac{2\pi}{T}$ $v = \frac{2\pi}{T}\sqrt{A^2 - y^2}$ $= \frac{2\pi}{1.6}\sqrt{0.20^2 - 0}$ $= 0.785\,m\,s^{-1}$	**GJU1** **K1** **GJU1**

(iii) At the lowest point, y = -A, a =?

$$a = -\omega^2 y$$
$$= -(\frac{2\pi}{T})^2 y$$
$$= -(\frac{2\pi}{1.6})^2(-0.20)$$
$$= 3.08\ m\ s^{-2}$$ **GJU1**

(upward and towards the equilibrium position) **J1**

(iv)



Correct label of x and y axes: D1
Correct shape: D1 **D2**

(v) The period of oscillation will beome shorter. **J1**

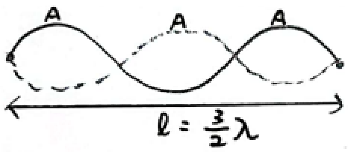
$T \propto \sqrt{m}$ **K1**

When m is reduced, the period T will be reduced as well. **K1**

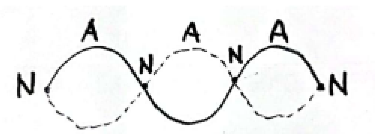
(b) Given L_o = 60.0 cm = 0.600 m, m = 10.0 g = 0.0100 kg, v = 210 m s^{-1}

(i)

$$\lambda = \frac{2l}{3}$$ **K1**
$$= \frac{2(0.600)}{3} = 0.400\ m$$ **GJU1**



(ii)



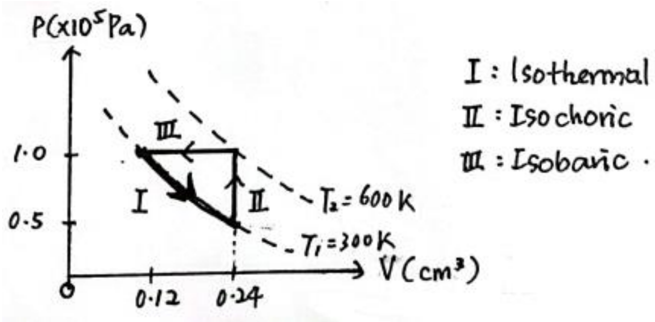
All positions of N labelled correctly: D1
All positions of AN labelled correctly: D1 **D2**

(iii)

$$f = \frac{v}{\lambda}$$
$$= \frac{210}{0.400} = 525\ Hz$$ **GJU1**

	(iv) $v=\sqrt{\frac{T}{\mu}} \quad and \quad \mu=\frac{m}{l}$ $v=\sqrt{\frac{Tl}{m}}$ $v^2=\frac{Tl}{m}$ $(210)^2=\frac{T(0.60)}{10.0\times10^{-3}}$ $T=735\ N$	K1 G1 JU1
	(c)(i) $y=5\sin[2(3)]\cos[3(1.0)]$ $=1.38\ m$ (ii) $A'=5\cos 3x$ $=5\cos[3(\frac{\pi}{3})]=-5.00\ m$ (iii) $x=\frac{1}{2}\lambda \quad and \quad k=\frac{2\pi}{\lambda}=3$ $x=\frac{1}{2}(\frac{2\pi}{k})$ $=\frac{1}{2}(\frac{2\pi}{3})$ $=1.05\ m$	GJU1 GJU1 K1 GJU1
7	(a) (i) $Y=\frac{FL_o}{A\Delta L}$ $=\frac{(100)(2.0)}{(2.0\times10^{-3})(1.0\times10^{-6})}$ $=1.00\times10^{11}\ Pa$ (ii) $U=\frac{1}{2}F\Delta L$ $=\frac{1}{2}(100)(2.0\times10^{-3})$ $=0.100\ J$	G1 JU1 GJU1
	(b) Given A_o= 1.0 cm^3, T_o= 150°C, T = 30°C, β=2α=2(1.1 x 10^{-5}) = 2.2 x 10^{-5} K^{-1} Using $A=A_o[1+\beta(T-T_o)]$ $=(1.0)[1+(2.2\times10^{-5})(30-150)]$ $=0.997\ cm^2$	G1 JU1
	(c) Given $L_X = L_Y$, $A_X = A_Y$	

	$(\frac{Q}{t})_X = (\frac{Q}{t})_Y$ $-k_1 A_X (\frac{\Delta T_X}{L_X}) = -k_2 A_Y (\frac{\Delta T_Y}{L_Y})$ $-k_1 A_X (\frac{80-100}{L_X}) = -k_2 A_Y (\frac{20-80}{L_Y})$ $k_1(-20) = k_2(-60)$ $\frac{k_1}{k_2} = \frac{60}{20} = 3$	**K1** **G1** **J1**
8	(a) Given n= 0.25 mol, T = 27 + 273.15 = 300.15 K (i) $< K_{tr} > = \frac{3}{2} kT$ $= \frac{3}{2}(1.38\times10^{-23})(300.15) = 6.21\times10^{-21} J$ (ii) $f = 5$ $U = \frac{f}{2} nRT$ $= \frac{5}{2}(0.25)(8.31)(300.15)$ $= 1.56\times10^{3}\ J$	**GJU1** **K1** **GJU1**
	(b) (i) $P_1V_1 = P_2V_2$ $(1.0\times10^5)(0.12) = P_2(0.24)$ $P_2 = 0.5\times10^5\ Pa$ (ii) $\frac{P_2}{T_2} = \frac{P_3}{T_3}$ $\frac{0.5\times10^5}{300} = \frac{1.0\times10^5}{T_3}$ $T_3 = 600\ K$ (iii) $W = nRT\ln(\frac{V_2}{V_1}) \quad and \quad PV = nRT$ $W = P_1V_1\ln(\frac{V_2}{V_1}) \quad or \quad P_2V_2\ln(\frac{V_2}{V_1})$ $= (1.0\times10^5)(0.12\times10^{-6})\ln(\frac{0.24}{0.12})$ $= 8.32\times10^{-3}\ J$	**GJU1** **GJU1** **K1** **G1** **JU1**

	(iv)  x and y axes are labelled correctly: D1 All process drawn correctly: D2 1 process wrong: D1 More than 1 process wrong: 0 mark	**D3**