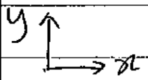
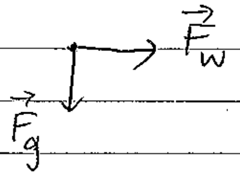
PHYS 1131 TEST 1 S2 2007

1(a)





$\vec{F}_w = 0.260\,\vec{i}\,N$

$\vec{F}_g = m\vec{g} = -0.215 \times 9.80\,\vec{j}\,N$
$= -2.11\,\vec{j}\,N$

(b) $\Sigma\vec{F} = m\vec{a}$

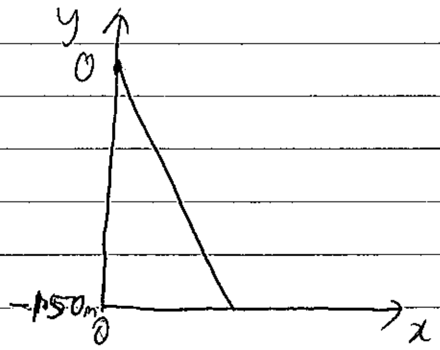
$\Rightarrow \vec{a} = \dfrac{\Sigma\vec{F}}{m} = \dfrac{\vec{F}_w + \vec{F}_g}{m} = \left(1.21\,\vec{i} - 9.80\,\vec{j}\right)\,ms^{-2}$

(c) Take $y_0 = 0$, $x_0 = 0$

$y = \cancel{v_{0y}}^{\,0} t + \frac{1}{2}a_y t^2 = -4.90\,t^2$

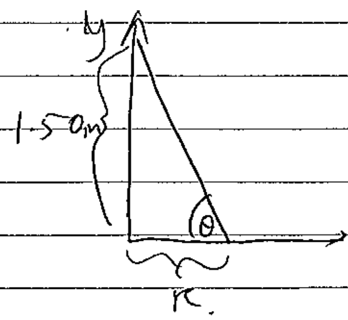
$x = \cancel{v_{0x}}^{\,0} t + \frac{1}{2}a_x t^2 = 0.605\,t^2$

$\Rightarrow y = -4.90\left(\dfrac{x}{0.605}\right) = -8.10\,x$



(d) $x = -y/8.10 \Rightarrow R = +1.50/8.10 = 18.5$ cm

$\theta = \tan^{-1}\left(\dfrac{1.50}{0.185}\right) = 83.0°$



(e). $v = \sqrt{v_x^2 + v_y^2}$

$v_x = \cancel{v_{x_0}}^{0} + a_x t = 1.21\,t$

$v_y = \cancel{v_{y_0}}^{0} + a_y t = -9.80\,t$

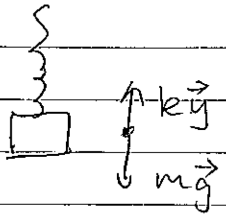
Find t: $y = -4.90\,t^2 \Rightarrow t = \sqrt{\frac{1.50}{4.90}} = 0.5533\,\text{s}$.

$\Rightarrow v_x = 1.21 \times 0.5533 = 0.6695\ \text{ms}^{-1}$

$v_y = -9.80 \times 0.5533 = 5.422\ \text{ms}^{-1}$

$\Rightarrow v = \sqrt{(0.670)^2 + (5.422)^2} = 5.46\ \text{ms}^{-1}$

2. (a)



$$\Sigma F_y = ky - mg = 0$$

$$\Rightarrow k = mg/y$$

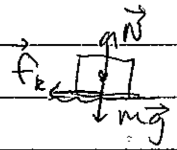
$$= 1.43 \times 9.80 / 0.0832$$

$$= 168 \ \mathrm{Nm^{-1}}$$

(b) All mechanical energy is lost due to friction between the block and surface,

$$\tfrac{1}{2} k x^2 - f_k l = 0$$

$$f_k = \mu_k N = \mu_k mg$$



$$\Rightarrow \tfrac{1}{2} k x^2 = \mu_k mg l$$

$$\Rightarrow \mu_k = \tfrac{1}{2} k x^2 / (mgl)$$

$$= \tfrac{1}{2} \times 168 \times (0.10)^2 / (1.43 \times 9.80 \times 0.662)$$

$$\simeq 0.0905$$

(c) (i) $$\tfrac{1}{2}(m_w + m_b) v^2 - \mu_k mgl = \tfrac{1}{2} k x^2, \quad l = (0.332 + 0.123)\,\mathrm{m}$$

$$\Rightarrow \tfrac{1}{2} m_w v^2 \simeq \tfrac{1}{2} k x^2 + \mu_k mgl$$

$$\Rightarrow v = \sqrt{\frac{2}{m_w}\left(\tfrac{1}{2} k x^2 + \mu_k mgl\right)}$$

$$= \sqrt{\frac{2}{1.43}\left(\tfrac{1}{2} \times 168 \times (0.123)^2 + 0.0905 \times 1.43 \times 9.80 \times 0.455\right)}$$

$$= 1.61 \ \mathrm{ms^{-1}}$$

(ii). Momentum conservation

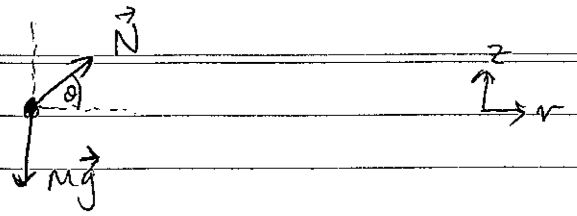
$$m_b u = (m_w + m_b) v$$

$$\Rightarrow u \simeq \frac{m_w}{m_b} v$$

$$= \frac{1.43}{0.00362} \times 1.61$$

$$\Rightarrow u = 636 \ ms^{-1}.$$

3. (a)



(b). The normal force (projection onto the horizontal) is responsible for the circular motion.

(c). $\sum F_z = N\sin\theta - mg = 0. \quad \Rightarrow N = mg/\sin\theta$

$\sum F_r = N\cos\theta = m\omega^2 r.$

$$\Rightarrow \quad m\omega^2 r = N\cos\theta$$

$$\Rightarrow \cancel{m}\omega^2 r = (\cancel{m}g/\sin\theta)\cos\theta.$$

$$\Rightarrow \omega^2 = g/r \cdot \frac{1}{\tan\theta}.$$

$$\Rightarrow \omega = \sqrt{\frac{g}{r\tan\theta}}.$$

4. $R = 1569 \text{ km}$
$g = 1.30 \text{ ms}^{-2}$

(a) $mg = \frac{GmM}{R^2}$ Weight of object near surface equals gravitational force

$\Rightarrow g = \frac{GM}{R^2}$

$\Rightarrow M = gR^2/G$

$= 1.30 \times (1569 \times 10^3)^2 / 6.67 \times 10^{-11}$

$\Rightarrow M = 4.80 \times 10^{22} \text{ kg}$.

(b) Escape speed.

Need sufficient kinetic energy K to get object to infinity at rest, where $U(r=\infty)=0$.

$\Rightarrow K_i + U_i = K_f + U_f = 0$

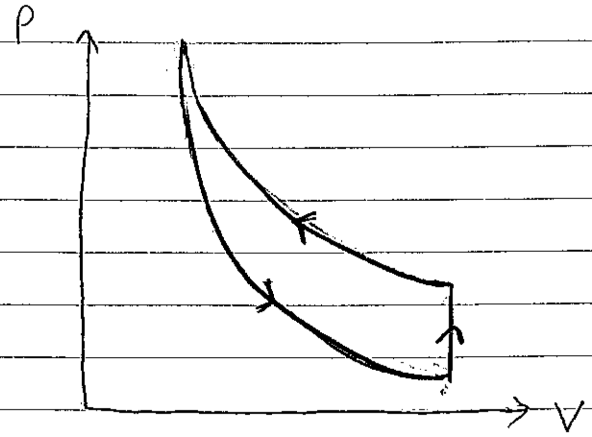
$\Rightarrow \frac{1}{2}\cancel{m}v^2 - \frac{G\cancel{m}M}{R} = 0$.

$\Rightarrow \frac{1}{2}v^2 = \frac{GM}{R}$.

$\Rightarrow v = \sqrt{\frac{2GM}{R}}$

$\Rightarrow v = \sqrt{\frac{2 \times 6.67 \times 10^{-11} \times 4.80 \times 10^{22}}{1569 \times 10^3}}$

$= 2.02 \text{ km s}^{-1}$

5. (a) 

[Explanation for diagram:
First, the piston is pulled rapidly – this corresponds to an adiabatic process. Therefore, the curve is steeper than an isotherm and the temperature of the gas is reduced. When the piston is held still, the gas equilibrates with the steam and water at 100°C; this corresponds to an increase in pressure at constant volume, $P = \left(\frac{nR}{V}\right) T$. When the piston is pushed slowly, there is enough time for the gas to be in equilibrium with the steam + water; therefore, the path follows an isotherm]

(b) Heat is added to the steam + water to bring about vaporisation,

$$Q = mL$$

$$= 0.052 \times 2.256 \times 10^{6}$$

$$= 117 \text{ kJ}$$

This is equal to the heat lost by the gas, therefore heat transferred to gas is

$$Q = -117 \text{ kJ}.$$

(c). $E_{int} \propto T$

$\Rightarrow \Delta E_{int} \propto \Delta T$

But the initial and final temperatures are the same (for the whole process)

$\Rightarrow \Delta E_{int} = 0.$

(d). Work done on gas W:

$$\Delta E_{int} = Q + W$$

$$\Rightarrow W = \Delta E_{int} - Q.$$

$$= 0 - (-117 \times 10^{3})$$

$$\Rightarrow W = +117 \text{ kJ}.$$

(This is consistent with the diagram – more work associated with compression than expansion, so work done is positive)