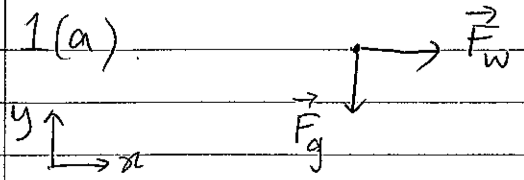
PHYS 1121 TEST 1 S2 2007

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) $\sum \vec{F} = m\vec{a}$

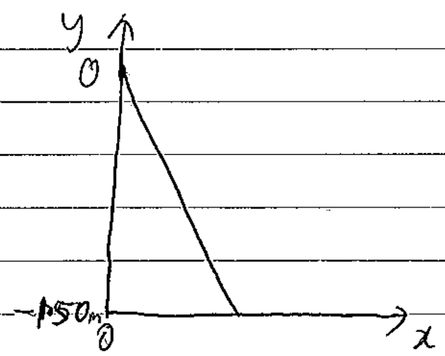
$$\Rightarrow \vec{a} = \frac{\sum \vec{F}}{m} = \frac{\vec{F}_w + \vec{F}_g}{m} = \left(1.21\,\vec{i} - 9.80\,\vec{j}\right)\ ms^{-2}$$

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

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

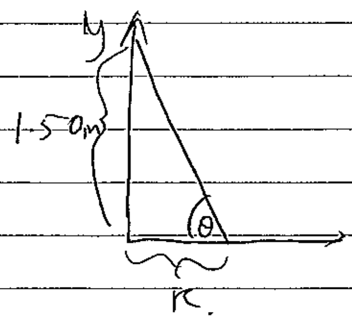
$$x = \cancel{v_{0x}}^{0} t + \tfrac{1}{2} a_x t^2 = 0.605\,t^2$$

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



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

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



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

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

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

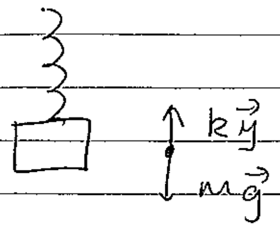
Find t: $y = -4.90\,t^2 \Rightarrow t = \sqrt{\frac{1.50}{4.90}} = 0.5533\,s$

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

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

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

2. (a)



$$\sum F_y = ky - m_w g = 0$$

$$\Rightarrow k = m_w g / y$$

$$= 1.43 \times 9.80 / 0.0832$$

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

(b)(i) No non-conservative forces acting, so mechanical energy is conserved:

$$\tfrac{1}{2} k x^2 = \tfrac{1}{2}(m_b + m_w) v^2$$

$$\Rightarrow v = \sqrt{kx^2 / (m_b + m_w)}$$

$$= \sqrt{168 \times (0.123)^2 / (1.43)}$$

$$= 1.33 \text{ ms}^{-1}$$

(ii) From momentum conservation

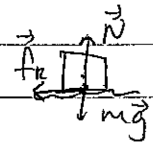
$$m_b u = (m_b + m_w) v$$

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

$$= \frac{1.43}{0.00362} \times 1.33$$

$$= 525 \text{ ms}^{-1}$$

(c) (i) $\frac{1}{2} k x^2 - F_k l = 0$



$f_k = \mu_k N = \mu_k m g$

$$\Rightarrow \frac{1}{2} k x^2 = \mu_k m g l$$

$$\Rightarrow \mu_k = \frac{1}{2} k x^2 / (m g l)$$

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

$$= 0.0905$$

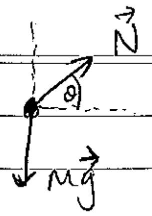
(ii) Mechanical energy lost due to friction between block and surface:

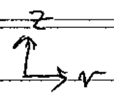
$$E_{lost} = \mu_k m g l$$

$$= 0.0905 \times 1.43 \times 9.80 \times (0.332 + 0.123)$$

$$\approx 0.577 \text{ J}$$

3. (a)





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

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

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

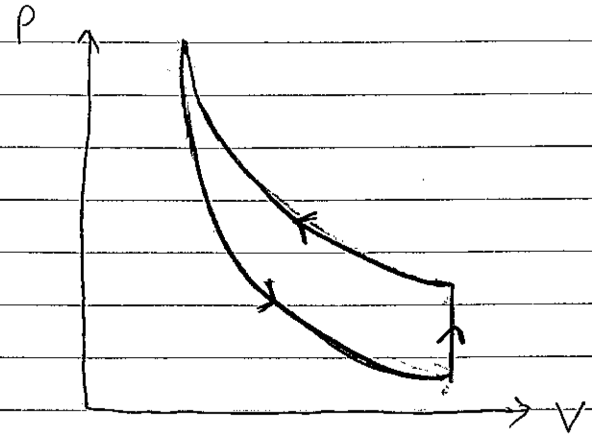
$\Rightarrow m\omega^2 r = N\cos\theta$

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

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

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

4. (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,

$$Q = mL$$

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

$$= 117\ kJ$$

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

$$Q = -117\ kJ.$$

(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:

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

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

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

$$\Rightarrow W = +117\ kJ.$$

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