VICTORIA JUNIOR COLLEGE

SUGGESTED SOLUTIONS TO 2015 H1P2 PHYSICS PRELIM EXAMS

1(a)(i) Considering motion up and along the incline, we have (taking y as the upward vertical direction).

$$u = \frac{u_y}{\sin\theta}, v = \frac{v_y}{\sin\theta} \text{ and } a = -g\sin\theta$$

Using $v = u + at$ up and along the incline,

$$\frac{10.2}{\sin\theta} = \frac{17.5}{\sin\theta} + (-9.81)(\sin\theta)(3)$$

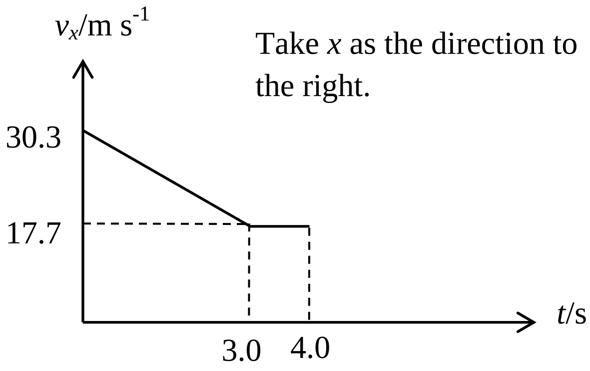
$\boldsymbol{\theta = 29.9°}$

1(a)(ii) $u = \dfrac{17.5}{\sin 29.9°}$,

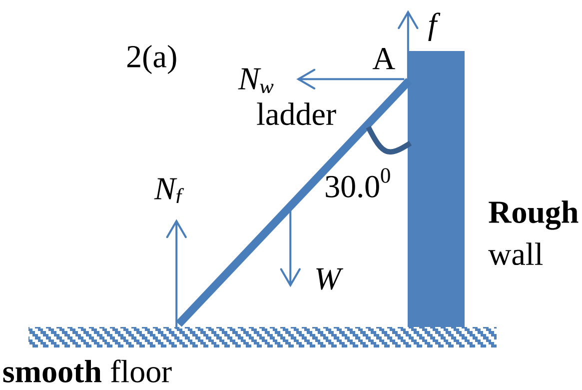
$\boldsymbol{u = 35.1 \text{ m s}^{-1}}$

1(b)

Take x as the direction to the right.



2(a)



The forces acting on the ladder are N_f, N_w, f and W which are the normal reaction force exerted by the floor on the ladder, the normal reaction force exerted by the wall on the ladder, force of friction between wall and ladder and the weight of the ladder respectively.

As the horizontal force N_w is unopposed by another horizontal force to the right, the ladder cannot be in translational equilibrium.

2(b)

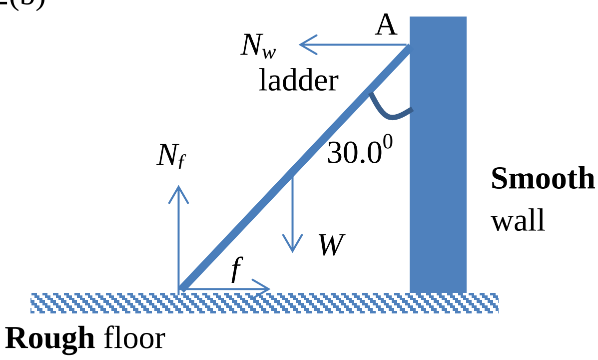


Fig. 2.1

Forces acting on the ladder are shown above. Let length of ladder be L.

For vertical equilibrium, $N_f = W = 200$ N

Taking moments about point A at the top of the ladder,

$$N_f(L\sin 30^0) = W(\frac{L}{2}\sin 30^0) + f(L\cos 30^0)$$

$\therefore f = 57.7$ N

Total reaction force acting on the foot of the ladder is

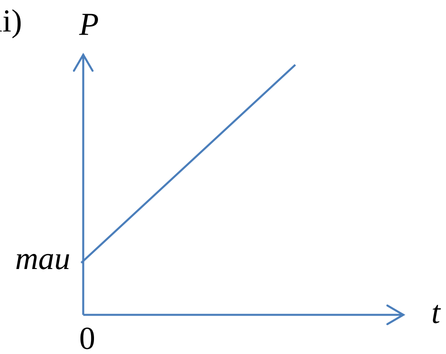
$$R = \sqrt{f^2 + N_f^2} = \sqrt{57.7^2 + 200^2}$$

$\approx$ **208 N**

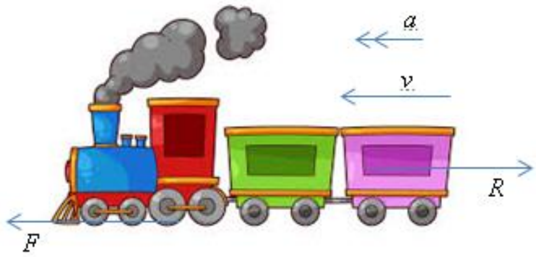
3(a)(i) Power is given by $P = Fv$

But $F = ma$ and $v = u + at$ Hence $P = (ma)(u + at)$ or $\boldsymbol{P = mau + ma^2t}$

3(a)(ii)



3(b) Given: v = 10 m s^{-1} ; a = 0.16 m s^{-2} ;
m = 3.0 x 10^{5} kg;; R = 3.0 x 10^{4} N; P = ?



By N2L, we have $F - R = ma$
Or $F = ma + R$
$P = Fv = (ma + R)v$
$= [(3.0\text{x}10^5)(0.16) + 3.0\text{x}10^4](10)$
= **7.8 x 10^{5} W**

4(a) Observations (State any 1)

- Existence of a threshold frequency of incident radiation below which no photoelectric emission can occur.

- Maximum kinetic energy of the emitted photoelectrons is independent of the intensity but on the frequency of the radiation.

- Photoelectric emission takes place instantaneously.

How the wave theory cannot account for each of the observations (Select 1):

According to the classical wave theory,

- The photoelectric effect should occur for any frequency of light, provided that the light intensity is sufficient to supply energy to eject photoelectrons.

- The kinetic energy of the photoelectrons should increase as the incident light is made more intense. Electrons should be able to absorb energy continuously from the electromagnetic waves. As the light intensity increases, energy should be transferred into the metal at a higher rate and the photoelectrons should be ejected with more kinetic energy.

- There should be a measurable time lag for the electrons to absorb enough energy in order to escape.

4(b)(i) Plate Y is positive with respect to X. All the photoelectrons emitted per second from plate X are swept across the space from plate X to Y resulting in a constant current.

4(b)(ii) From Einstein's photoelectric equation, we have $hf = \phi + V_s e$.
A bigger stopping potential (from V_1 to V_2) is possible with an increase in frequency f of the incident radiation.

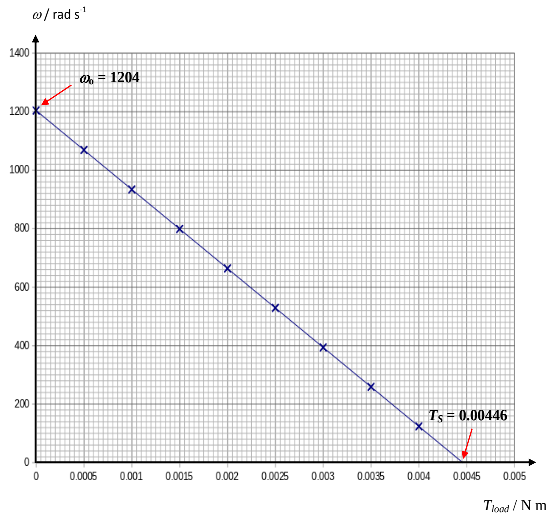
5(a) $\Delta E = \dfrac{hc}{\lambda}$

$= \dfrac{6.63\times10^{-34}\times3.00\times10^{8}}{103\times10^{-9}} = 1.93\times10^{-18}\,\text{J}$
$= 12.1\text{eV}$
Hence the transition is from **n=3 to n=1.**

5(b) There will be no electron transitions in the hydrogen gas atoms.

The incident light of energy 12.5 eV does not match any of the energy gaps between the ground state and an excited state.

6(a) & (b)



6(c)) $T = kI \qquad - (1)$

$$I = \frac{V - V_e}{R} \qquad - (2)$$

$V_e = k\omega \qquad - (3)$

$T = T_{load} + T_f \qquad - (4)$

Substitute $I = T/k$ from (1) and $V_e = k\omega$ from (3) into (2):

$$\frac{T}{k} = \frac{V - k\omega}{R}$$

$$\frac{RT}{k} = V - k\omega$$

$$k\omega = -\frac{RT}{k} + V$$

$$\boldsymbol{\omega = -\left(\frac{R}{k^2}\right)T + \frac{V}{k}}$$

But, $T = T_{load} + T_f \qquad - (4)$

Hence,

$$\omega = -\left(\frac{R}{k^2}\right)\left(T_{load} + T_f\right) + \frac{V}{k}$$

$$\omega = -\left(\frac{R}{k^2}\right)T_{load} + \frac{V}{k} - \left(\frac{R}{k^2}\right)T_f$$

$$\boldsymbol{\omega = -\left(\frac{R}{k^2}\right)T_{load} + A}$$

where A is a constant comprising the remaining terms on the RHS of the equation. (proved)

6(d) From the equation in (c),

the gradient of the ω-T graph = $-\left(\frac{R}{k^2}\right)$

$$\frac{1000 - 0}{0.00075 - 0.0045} = -\frac{14.5}{k^2}$$

k = **0.00733 = 7.33 x 10^{-3} N m A^{-1}**.

6(e) $T = T_{load} + T_f \qquad - (4)$

$\therefore T = 2.00 \times 10^{-3} + 9.0 \times 10^{-5}$

$\qquad = \mathbf{2.09 \times 10^{-3}}$ **N m**

6(f) From the ω-T_{load} graph,

when T_{load} = 2.00 × 10^{-3} N m,

ω = **670 rad s^{-1}**.

6(g)) $T = kI \qquad - (1)$

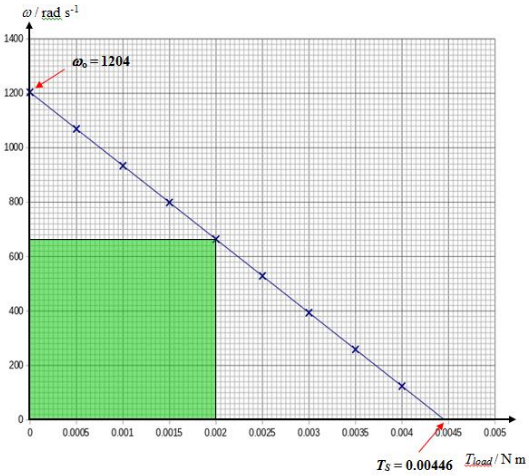
$\therefore 2.09 \times 10^{-3} = 0.00733I$

$\therefore I$ = **0.285 A**

6(h) $P_{mech} = T_{load} \times \omega$

$\qquad = 2.00 \times 10^{-3} \times 670 = \mathbf{1.34}$ **W**

6(i)



6(j) Efficiency,

$$\eta = \frac{P_{mech}}{P_{in}} = \frac{P_{mech}}{V \times I}$$

$$= \frac{1.34}{9.0 \times 0.285}$$

$$= \mathbf{0.52}$$

7. Given: M = 2.0 kg; u_1 = 3.0 m s^{-1};
m = ?; $u_2 = 0$; $v_2 = 1.6$ m s^{-1}

7(a) Take right as the positive direction. From the Impulse-Momentum Theorem, the change in momentum (or impulse) of the 2.0 kg cart is the area under the F-t graph.

$$Mv_1 - Mu_1 = -\frac{1}{2}(1.0\text{x}10^{-3})(10\text{x}10^{3})$$

(Note: the 2.0 kg cart suffers a negative impulse due to retardation during impact.)

$v_1 = \dfrac{-5+(2.0)(3.0)}{2.0}$ = **0.50 m s^{-1}**

The positive value of v_1 indicates that it continues to move to the right after the collision.

7(b) From p.o.c.o.m.,

$Mu_1 + 0 = Mv_1 + mv_2$

(2.0)(3.0)=(2.0)(0.50)+m(1.6)

$\therefore$ ***m* = 3.13 kg.**

7(c) Loss in KE =

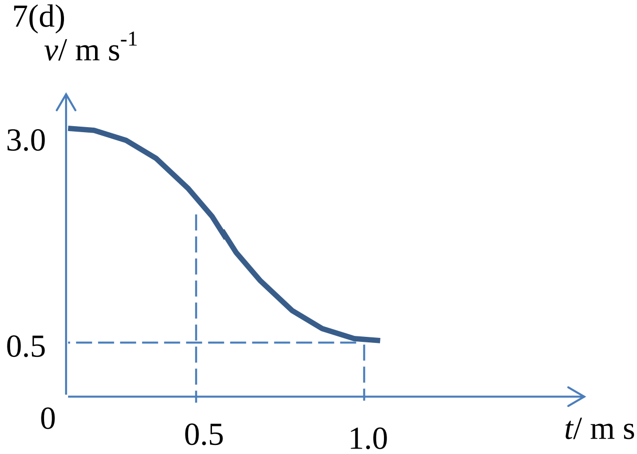
$\frac{1}{2}Mu_1^{\ 2} - \left(\frac{1}{2}Mv_1^{\ 2} + \frac{1}{2}mv_2^{\ 2}\right)$

$= \frac{1}{2}(2.0)(3.0^2) - \frac{1}{2}(2.0)(0.50^2) - \frac{1}{2}(3.13)(1.6^2)$

≈ **4.7 J**

Since total KE of the system is not conserved, the collision is inelastic.

7(d)



7(e) Acceleration is gradient of v- t graph at t = 3.0 s = constant

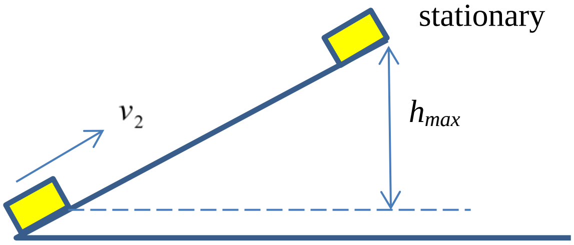
$= \dfrac{0.50-1.6}{3.5-2.0} \approx$ **-0.733 m s^{-2}**

7(f) Distance covered = area under $v-t$ graph

= (1.6 x 2) + $\frac{1}{2}(1.6+0.5)(1.5)$ +(0.5 x 1.5)

= **5.53 m**

7(g) The cart goes up the slope since it suffers a decreasing speed from t = 2.0 s to 3.5 s.



From conservation of energy, loss of KE = gain in GPE

$\frac{1}{2}m\left(v_2^{\ 2} - v_3^{\ 2}\right) = mgh_{max}$ where

$v_3 = 0.50\ \mathrm{m\,s^{-1}}$

$h_{max} = \dfrac{\left(v_2^{\ 2} - v_3^{\ 2}\right)}{2g} = \dfrac{\left(1.6^2 - 0.50^2\right)}{2(9.81)}$

≈ **0.118 m**

8(a) To obtain a maximum, path difference = $n\lambda$

For Experiment 1,

1.20 = nv/850 (1)

For the next higher maximum,

1.20 = (n+1)v/1133 (2)

Solving, we have ***v* = 340 m s^{-1}**

8(b) For Experiment 2, $y = \lambda D/d$ where y = distance between two adjacent maxima.

3.82 x 2 = λ(100)/0.300

λ = 0.0229 m

$v = f\lambda$ = 15,000(0.0229) = **343 m s^{-1}**

8(c)(i) Stationary waves are set up inside the tube.

There are positions where the air particles do not get displaced at all, and the powder will form heaps at these positions. These positions are the displacement nodes.

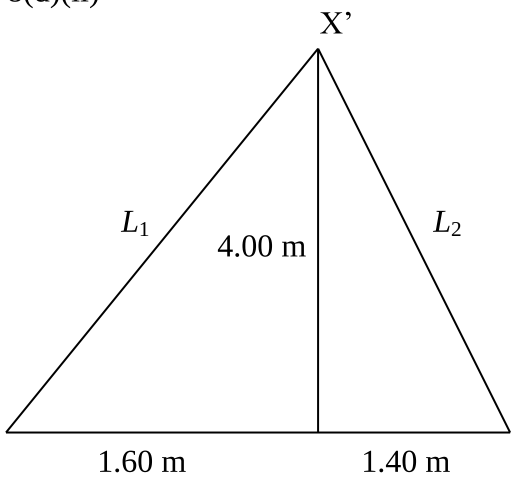
8(c)(ii) Referring to Fig. 8.2, we have $3\lambda/2 = 0.150$
$\therefore \lambda = 0.100$ m

$v = f\lambda = (3400)(0.100)$
$= \mathbf{340\ m\ s^{-1}}$

8(c)(iii) A standing wave is no longer produced within the tube.

8(d)(i) A maximum is obtained since the path difference from the two in-phase sources is zero.

8(d)(ii)



Let the first sound minimum occur at X'.

Path difference $L_1 - L_2 = (1.60^2 + 4.00^2)^{1/2} - (1.40^2 + 4.00^2)^{1/2}$
$= 0.0702$
$= (1/2)\lambda$ for first minimum.
$\lambda = 0.140$ m
$v = f\lambda = 2400 \times 0.140$
$= \mathbf{336\ m\ s^{-1}}$

8(e) Average speed of sound in air
$= (340 + 343 + 340 + 336)/4$
$= 340\ \mathrm{m\ s^{-1}}$

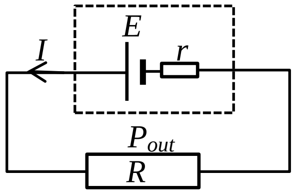
Since the extreme values are 336 m s^{-1} and 343 m s^{-1}, a conservative estimate of the uncertainty will be $\pm$ 4 m s^{-1}.
Hence $\boldsymbol{v} = \mathbf{(340 \pm 4)\ m\ s^{-1}}$.

9(a) (i) The e.m.f. of a source refers to the total electrical energy that the source can transform from other forms of energy per unit charge delivered in a circuit.

9(a)(ii)1.

Not all the electrical power generated by the source will be available to the external circuit.
Some power will be lost in the source itself because of the internal resistance resulting in an efficiency of less than 100%.

9(a)(ii)2.



The efficiency of the power output of the source is given by:

$$\eta = \frac{I^2 R}{I^2 R + I^2 r} = \frac{\boldsymbol{R}}{\boldsymbol{R} + \boldsymbol{r}}$$

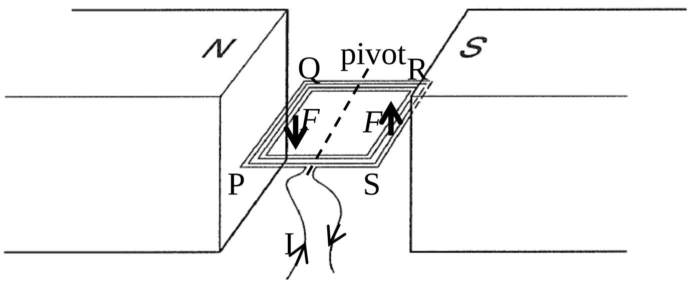
9(b) (i) The resistance of the coil, $R = \dfrac{\rho L}{A}$

$$= \frac{(9.0\mathrm{x}10^{-8})(40\mathrm{x}0.24)}{\pi(0.25\mathrm{x}10^{-3})^2} = 4.4\,\Omega$$

Thus, the current through the coil, $I = \dfrac{V}{R}$

$= 2.0/4.4 = \mathbf{0.45\ A}$

9(b)(ii)



9(b)(iii) The force acting on PQ and RS,
$F = NBILsin\theta$
$= (4.5 \times 10^{-2})(0.45)(40 \times 0.060)$
= **4.86×10^{-2} N.**

9(b)(iv) The force on PQ and RS will constitute a couple
which will tend to rotate the coil in an anti-clockwise direction.

9(b)(v)1. The initial couple on the coil will cause it to rotate about the pivot in an anti-clockwise direction.
After passing through the vertical plane, the coil will experience a couple in the opposite direction.
The coil will thus rotate briefly back and forth about the vertical plane.
It will finally come to rest.

(b)(v)2. Motion of the coil ceases when its rotational energy has all been converted into work done to overcome friction.

9(b)(v)3. When it has come to rest, the plane of the coil will be vertical.

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