HWA CHONG INSTITUTION

Sample Paper B
Secondary 3 Physics

Paper 1

1)	**D**	11)	**B**	21)	**D**
2)	**A**	12)	**D**	22)	**B**
3)	**A**	13)	**C**	23)	**A**
4)	**D**	14)	**A**	24)	**B**
5)	**C**	15)	**D**	25)	**A**
6)	**C**	16)	**B**	26)	**C**
7)	**A**	17)	**C**	27)	**B**
8)	**A**	18)	**C**	28)	**C**
9)	**C**	19)	**B**	29)	**B**
10)	**D**	20)	**C**	30)	**A**

Paper 2

SECTION A (40 MARKS)

1) In Oishi Sushi restaurant, after customers had placed their orders via a touch screen menu, shortly after, automated carriers would transport the ordered food from the kitchen to them via high speed tracks. After the customers had removed the food from the carriers, they would press a button located at their booths to send the carriers back to the kitchen. Fig. 1.1 shows two such empty carriers **A** and **B** on separate tracks at booths 1 and 2 respectively. Both carriers were at rest and directly below the booth buttons.

Image source: http://www.canstockphoto.com/illustration/shinkansen.html

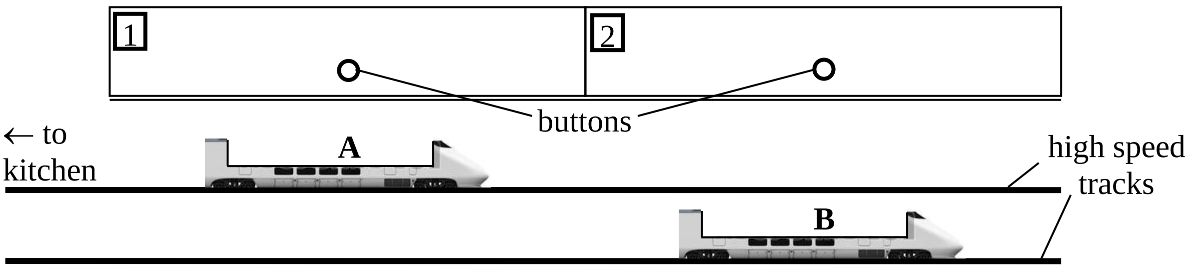


Fig. 1.1

Fig. 1.2 represents the motion of carriers **A** and **B** over a period of 25 seconds.

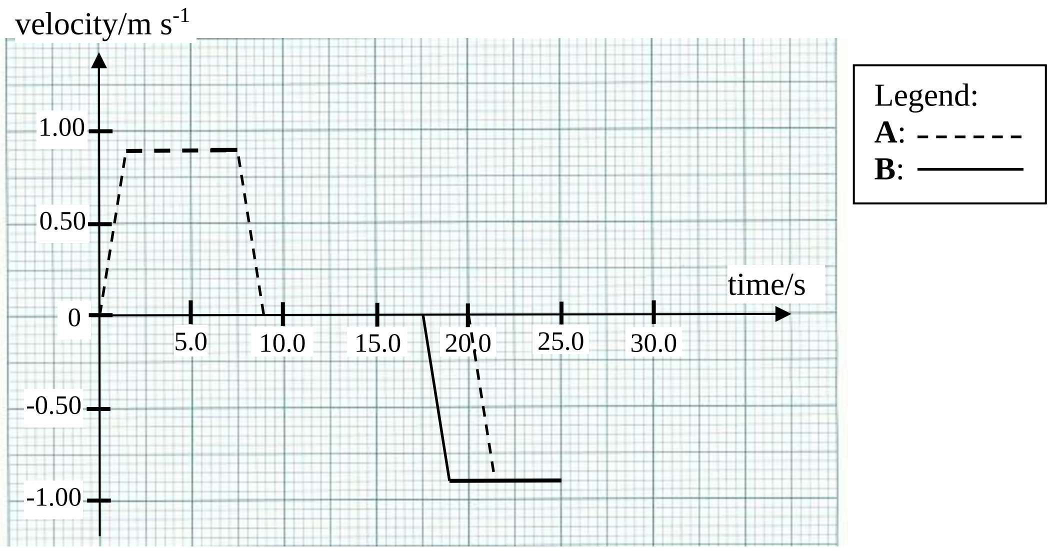


Fig. 1.2

At t = 0 s, carrier **A** was at the kitchen whereas carrier **B** was at booth 2.

(a) Describe the resultant force acting on carrier **A** for its journey from the kitchen to booth 1. [3]

t = 0 s to t = 1.5 s: constant positive resultant force [1]
t = 1.5 s to t = 7.5 s: zero resultant force [1]
t = 7.5 s to t = 9.0 s: constant negative resultant force [1]

(b) Carrier **A** was transporting a bowl of soup from the kitchen to booth 1. On Fig. 1.3, sketch the soup level if carrier **A** had

(i) moved with constant velocity, [1]

(ii) suddenly accelerated from rest. [1]

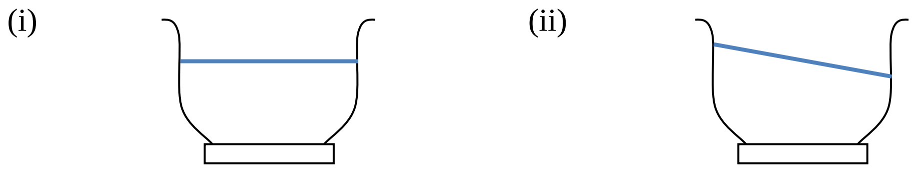


Fig. 1.3

(c) Both carriers were at rest at booths 1 and 2 during a common time range from t_1 s to t_2 s. State the values of t_1 and t_2. [1]

From $t_1 = 9.0$ s to $t_2 = 17.5$ s

(d) Given carrier **B** left booth 2 and was directly below carrier **A** just when it was about to leave booth 1,

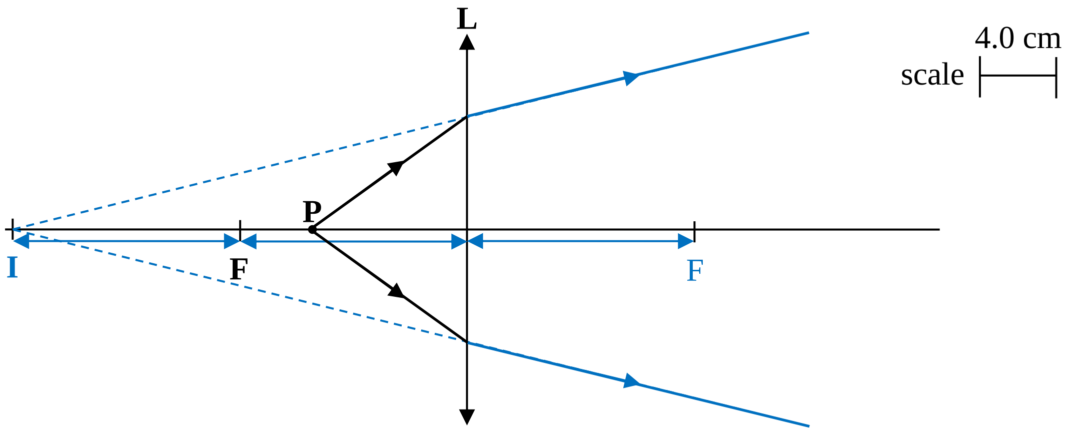
(i) calculate the distance between the two booth buttons. [2]

$s = 1/2\ [(0.90)(2.5 + 1.0)]$ [1]
$= 1.6$ m (correct to 2 s.f.) [1]

(ii) determine the magnitude and direction of carrier B's initial acceleration. [2]

$a = (0.90 - 0) / 1.5$
$= 0.60\ m/s^2$ (correct to 2 s.f.) [1],
towards the kitchen/ to the left. [1] or $a = -0.60\ m/s^2$

2) Fig. 2.1 shows a scale diagram of the paths of light rays from an object point **P** passing through a thin converging lens **L** of focal point **F**.



Two construction lines: 1 m
Two solid rays with arrows: 1 m

Fig. 2.1

(a) Given the image is 24.0 cm from the lens, on Fig. 2.1, mark out the position of the image and label it **I**. [1]

(b) On Fig. 2.1, complete the path of the two rays to show how the image **I** is produced by the lens. Show any construction lines clearly. [2]

(c) Explain, in terms of light rays, if image **I** is a real image or virtual image. [2]

Image I is a virtual image. [1]
This is because light rays do not meet / converge at the image. [1] [Allow e.c.f.]

3) Fig. 3.1 shows a cycle pump connected to an airtight glass flask and a pressure gauge.

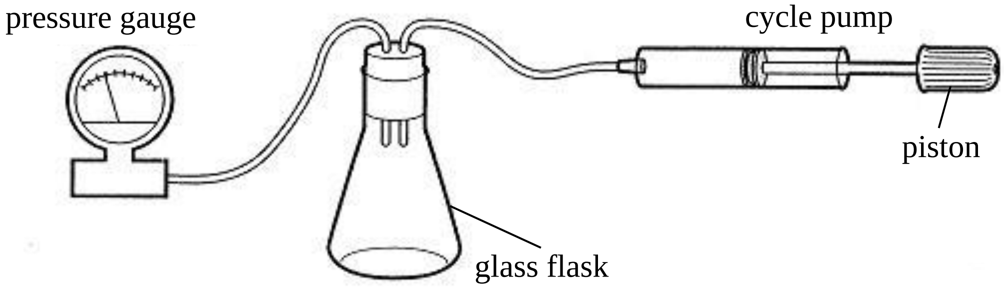


Fig. 3.1

(a) State the change in the reading on the pressure gauge when the piston of the cycle pump was pushed in slowly. [1]

The reading increases / rises. [1]

(b) Using the kinetic model of matter, explain how the pressure change in (a) occurred. [3]

When the piston was pushed in,
the <u>average separation / distance between air molecules decreases</u> or <u>number of molecules per unit volume increases</u> [1] which causes
the <u>frequency of collisions of air molecules with flask's wall</u> to <u>increase</u> [1]
Since the <u>force</u> acting on the flask's wall <u>per unit area increases</u>, its pressure increases. [1]

(c) Describe another method to bring about the same pressure change in (a) other than pushing in the piston of the cycle pump. [1]

Heat up the flask or cycle pump / use a smaller flask

4) Fig. 4.1 shows a trapezoidal rough wooden block **PQRS**. A hand exerted a constant force of magnitude *f* along **PQ** on a brick of mass 1.2 kg to slide it continuously at constant speed from **P** to **Q.** Subsequently, the brick is moved from **Q** to **R** and pushed off the edge of side **R** so that it dropped vertically to the ground as shown.

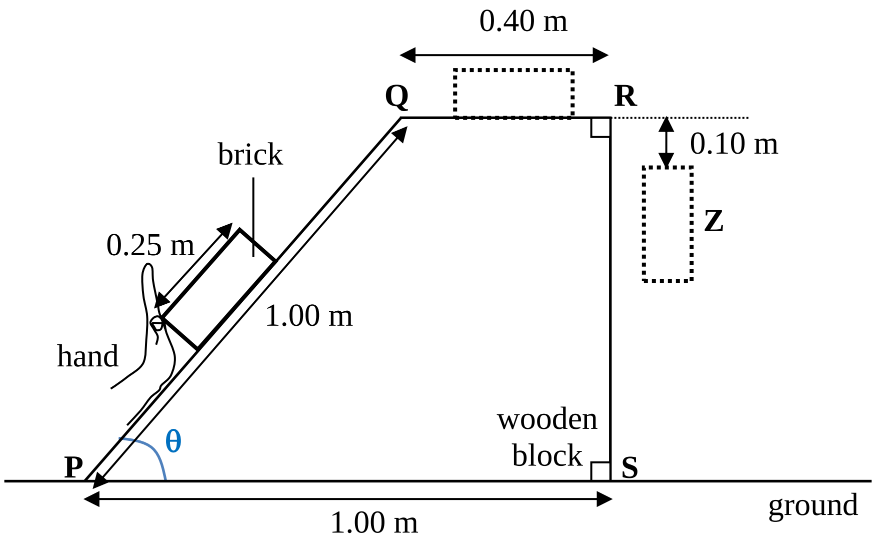


Fig. 4.1

(a) State a pair of action-reaction forces involving the brick as it moves from **P** to **Q**. [1]

(Normal) force by block on brick and force by brick on block
(Normal) force by hand on brick and force by brick on hand
(Frictional) force by block on brick and force by brick on block
(Gravitational) force by Earth on brick and force by brick on Earth
[Any 1] (Type of force need not be explicitly stated.)

(b) Calculate

(i) the work done against gravity to move the block from **P** to **Q**. [2]

Work done against gravity = mgh
$= 1.2\ (10)(1.00^2 - 0.60^2)^{0.5}$ [1]
$= 1.2\ (10)(0.80)$
= 9.6 J [1]

OR

Work done against gravity = // component of weight X 1.00 m
= 1.2 (10) sin θ X 1.00
= 1.2 (10) (0.80/1.00) X 1.00 [1]
= 9.6 J [1]

(ii) the magnitude of constant force f if work done against friction was 2.4 J as it moved from **P** to **Q**. [2]

Work done by hand = 9.6 J + 2.4 J
= 12.0 J [1]
= f X 1.00 m
$\therefore f$ = 12.0 N [1]

(c) When the block was at position **Z** as shown in Fig. 4.1, its velocity was 2.0 m s^{-1}.

(i) If the block was falling freely, calculate the time taken to reach the ground from position **Z**. [3]

Can also solve by conservation of energy:
K.E. at Z + G.P.E. at Z = K.E. at ground.

$v^2 = u^2 + 2as$ [u = 2.0 and a = g] $= 2.0^2 + 2(10)(0.80 – 0.10 – 0.25)$ **[1]** v = 3.61 m s^{-1} a = (v – u)/t t = (3.61 – 2.0)/10 **[1]** = 0.16 s (to 2 s.f.) **[1]**	$s = ut + 1/2\ a\ t^2$ [u = 2.0 and a = g] $(0.80 - 0.10 – 0.25) = 2.0\ t + 1/2\ (10)(\ t^2)$**[1]** By solving quadratic equation, working: **[1]** t = 0.16 s or t = - 0.56 s (rejected) t = 0.16 s (to 2 s.f.) **[1]**

(ii) Explain, in terms of forces acting on the block, how the time calculated in (c)(i) would differ if air resistance were present as it fell to the ground. [2]

If air resistance were present, as air resistance increases with speed,
the <u>net force</u> acting on the brick <u>decreases</u>, [1]
its magnitude of acceleration decreases,
thus the time calculated in (c)(i) would be <u>greater / increase / longer</u>. [1]

5) Fig. 5.1 shows the displacement-time graph of a particle of a visible light wave of wavelength λ.

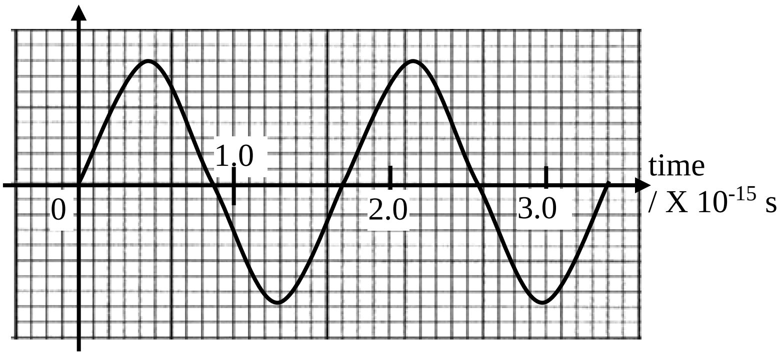


Fig. 5.1

colour	wavelength / nm
violet	380 – 450
blue	450 – 495
green	495 – 570
yellow	570 – 590
orange	590 – 620
red	620 – 750

Fig. 5.2

(a) (i) Calculate the frequency of this wave. [1]

Period = 1.7 X 10^{-15} s
Frequency = 1 / period
= 5.88 X 10^{14} Hz
= 5.9 X 10^{14} Hz (to 2 s.f.) [1]

(ii) Given the speed of light in air is 3.0 X 10^{8} m/s, determine λ, the wavelength of this wave. [2]

[E.c.f.: Award 2 m for correct working in (a)(i)]

$v = f\lambda$

3.0 X 10^{8} = 5.88 X 10^{14} (λ) [1]

λ = 5.1 X 10^{-7} m (to 2 s.f.) or 510 nm [1]

(b) A light ray of wavelength λ is incident on a glass prism as shown in Fig. 5.3.

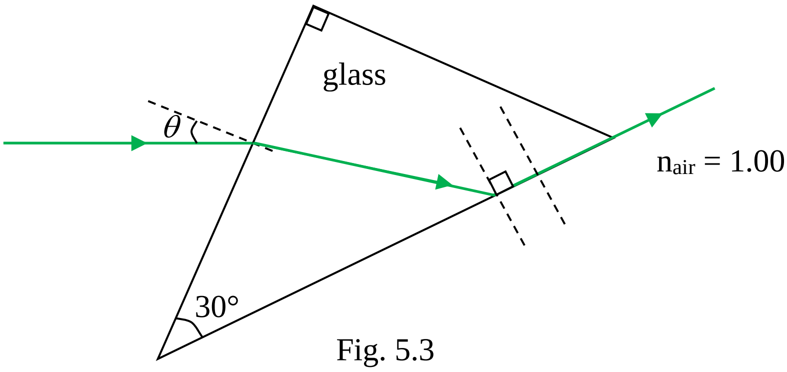


Fig. 5.3

(i) If the absolute refractive index of the glass prism for this light is 1.47, calculate the critical angle for this light passing from glass into air. [2]

$n_g \sin\theta_g = n_a \sin\theta_a$ => $1.47 \sin\alpha = (1.00)\sin 90^{\circ}$ [1]

critical angle, $\alpha = 42.86^{\circ}$ = 42.9^{o} (to 3 s.f.) [1]

(ii) Using your answer from (b)(i), calculate the value of the angle θ. [2]

angle of refraction at surface AB = 180^{o} - (90^{o} - 42.86^{o}) - 30^{o} - 90^{o} [1]
= 12.86^{o}

$n_a \sin\theta_a = n_g \sin\theta_g$ => $1.00 \sin\theta = (1.47)\sin 12.86^{\circ}$

θ = 19.1^{o} (to 3 s.f.) [1]

(iii) Using information from Fig. 5.2, state and explain the change in the absolute refractive index of glass if the light ray of wavelength λ is replaced by a ray of red light directed along the same path with an angle of incidence of θ. [3]

$\lambda_{red} > \lambda_{\lambda}$ or $f_{red} < f_{\lambda}$ [1],
$v_{red} > v_{\lambda}$ / red light is refracted less than green light / greater angle of refraction / bent less towards normal [1]
$\therefore n_{red} < n_{\lambda}$ [1]

SECTION B (30 Marks)

Answer question Q6, Q7 and either Q8A or Q8B in this section

6) In the quest to harness alternative sources of energy, solar energy is one of the most popular option. Solar cells or photovoltaic (PV) cells are used to convert light energy from the sun into electrical energy. Currently, the semiconducting materials used in PV cells are either crystalline silicon wafers or thin, good light-absorbing films deposited on coated glass or stainless steel sheets.

Image source:
http://www.engineering.com/SustainableEngineering/RenewableEnergyEngineering/SolarEnergyEngineering/Photovoltaics/tabid/3890/Default.aspx

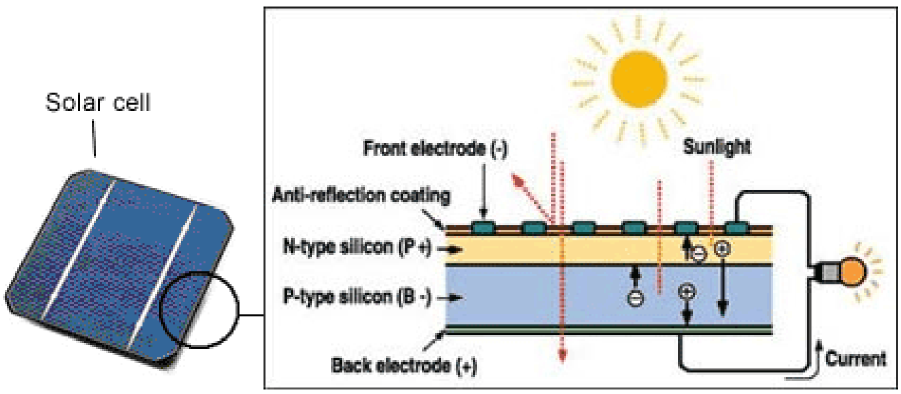


Fig. 6.1

Fig. 6.1 shows a PV cell made up of two layers of chemically treated crystalline silicon (which is the N-type silicon and the P-type silicon) bonded together. When sufficient light energy falls on the cell, the positive and negative charges move across the boundary of the layers to create a voltage difference between the front and the back of the cell.

Typically, the voltage, V, provided by a PV cell is about 0.5 V and the maximum current, I, which can be drawn is about 3 A. By soldering 36 PV cells in series for example, the result is a PV module which provides a voltage of 18 V and delivers a maximum power output, P, of 54 W, given power, $P = VI$.

In recent years, there has been more research done on "Black silicon" or crystalline silicon PV cells that have been treated so that they appear to be black on the surface in hope that this technology would increase the efficiency of the PV cell.

(a) Suggest a reason why treating the silicon PV cells black would possibly increase its efficiency. [1]

Black surfaces absorb radiant heat / radiation / light energy / solar energy well.
(Wrong: good emitters of radiant heat / absorbs heat / thermal energy / energy)

(b) (i) A crystalline PV module combines 40 PV cells of 0.5 V, 3 A in series. Calculate the maximum power output, in W, delivered by this PV module. [2]

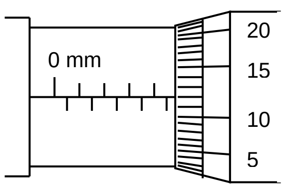
0.5 x 3 X 40 [1]
= 60 W (to 1 s.f.) [1]

(ii) 10 such PV modules in (b)(i) are mounted in a PV array. If a household has 2 such PV arrays to support its daily consumption of energy which is 31.6 kW h (kilowatt hour) on average, calculate the estimated percentage of energy provided by the array system when it had received approximately 5.0 hours of strong sunlight on a sunny day. [3]

(60 W X 10 X 2 X 5.0 h) [1] / 1000 = 6.0 kWh of solar energy provided
Estimated percentage of energy provided = 6.0 / 31.6 x 100 [1]
= 19 % (to 2 s.f.) or
20 % (to 1 s.f.) [1]

(c) Fig. 6.2 shows the micrometer screw gauge readings to measure the thickness of a crystalline silicon PV cell.

Fig. 6.2



(i) State the measured thickness of the cell in Fig 6.2. [1]

4.50 + 0.12 = 4.62 mm

(ii) Calculate the thickness of a thin film PV cell which is 90 times thinner than the crystalline silicon PV cell shown in Fig. 6.2. Express your answer in microns given that 1 micron is equal to 1 micrometre. [2]

4.62 / 90 [1]
= 0.0513 mm
= 51.3 μm or microns (correct to 3 s.f.) [1]

(iii) What can the engineer do to obtain a more accurate reading for the thickness of the cell? [1]

He can find the average thickness of the cell by taking another two measurements at different parts of it.

7) Fig. 7.1 shows a girl of mass 32 kg who was about to sit on a swing's seat of mass 2 kg. Fig. 7.2 shows the side view of the girl at the instant she lifts both her feet off the ground during her swinging motion. Position **X** is the highest point of her entire motion and at **X**, she was momentarily at rest.

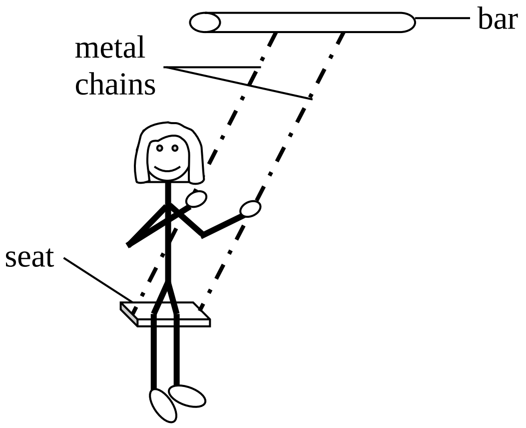


Fig. 7.1

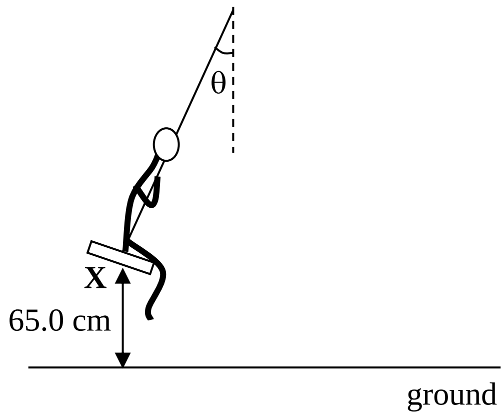


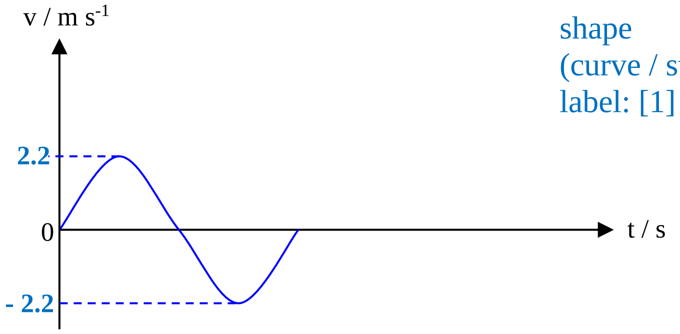
Fig. 7.2

Assume the metal chains are always taut during her motion and neglect air resistance.

(a) Calculate the speed of the swing's seat at the lowest point of its motion, which is 40.0 cm vertically above the ground. [2]

By COE, mgh at **X** = 1/2 mv^2 at lowest point
$v = \sqrt{(2gh)} = \sqrt{2 (10)(0.25)}$ [1]
$= 2.2$ m/s (correct to 2 s.f.) [1]

(b) On Fig. 7.3, sketch and label the velocity-time graph of the swing's seat for one complete oscillation given that at t = 0 s, it is at position **X**. Take the left to right direction as the positive direction. [2]



shape
(curve / straight line): [1]
label: [1]

Fig. 7.3

(c) By considering the girl and the swing's seat as one body, Fig. 7.4 shows the free-body diagram of the body at position **X**.

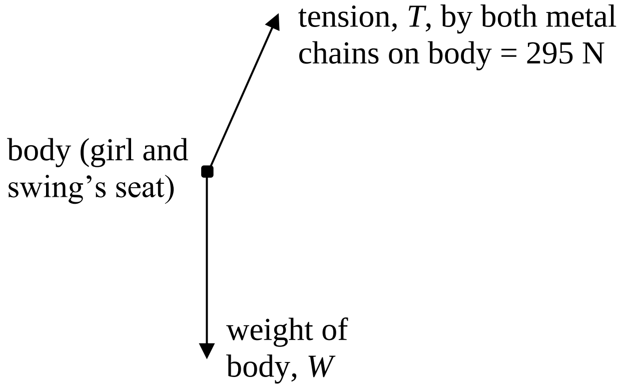


Fig. 7.4

Determine the weight of the body, *W*. [1]

W = (32 + 2)(10) = 320 N

(d) Given the resultant force at position **X** for Fig. 7.4 acts perpendicularly to the tension *T*.

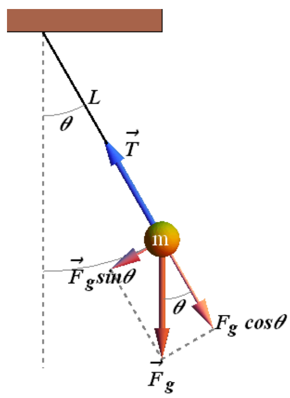
By drawing a scale diagram or otherwise (support with an appropriate illustration), determine

(i) the magnitude of the resultant force at position **X**, [3]

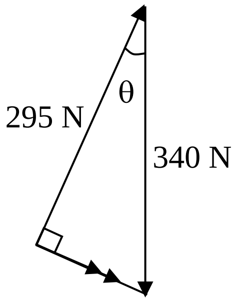
(ii) the value of angle θ. [1]

Note:

1) At X, the tension and weight act as shown in diagram on the right. The resultant force is actually the weight component ⊥ to tension.



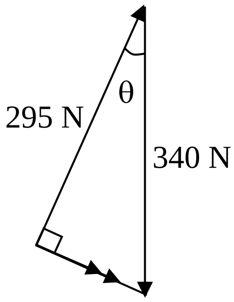
<u>Scale diagram:</u>
Scale: 1.0 cm represent 50 N [1]
Diagram: [1]



R = <u>170 N (acceptable: 160 - 180 N)</u> [1]

θ = <u>30° (acceptable: 28° - 32°)</u> [1]

<u>Calculation:</u>
Diagram: [1]



R = $\sqrt{(340^2 - 295^2)}$ = <u>170 N (to 2 s.f.)</u> [1]

cos θ = 295 / 340
θ = 29.81 = <u>30° (to 2 s.f.)</u> [1]

Correct working for R and θ: [1]

(e) Describe the change in the magnitude of the resultant force as the swing moved from position **X** to the lowest point of its motion. [1]

From **X**, the magnitude decreases until zero at the lowest point of its motion.

EITHER

8A) Fig. 8A.1 shows the parts of a 1500 W electric kettle.

Image source: http://www.remodelista.com/files/styles/733_0s/public/Electric-Tea-Kettle-Breville.jpg

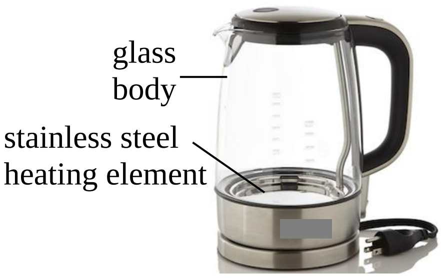


Fig. 8A.1

material	stainless steel	borosilicate glass
density / g cm^{-3}	8.0	2.2
specific heat capacity / J kg^{-1} K^{-1}	500	830
linear thermal expansion coefficient / μm m^{-1} K^{-1}	16.9	3.25
thermal conductivity / W m^{-1} K^{-1}	15.9	1.14

Fig. 8A.2

Fig. 8A.2 shows the properties of the two materials used to make the kettle.

(a) The electric kettle has a borosilicate glass body with a stainless steel heating element.
Using information from Fig. 8A.2, state and explain each of the following,
(i) **two** advantages of using borosilicate glass as the body
(ii) **one** advantage of using stainless steel as the heating element
for the kettle shown in Fig. 8A.1. [3]

(i) Borosilicate glass has
- a low density which makes the kettle have less weight [1]
- a low thermal conductivity which better insulates water in the kettle / reduces thermal energy transferred to the surroundings [1]
(X: high shc because difference in values not sufficiently significant.
X: low thermal expansion coefficient ∴ less likely to crack -> Reason for cracking is uneven expansion.)

(ii) Stainless steel has
- a high thermal conductivity which enables water to be heated up quickly. [1] **(X: low shc because difference in values not sufficiently significant.)**

(b) It is observed that at the base of the kettle, a gap is purposely left between the stainless steel heating element and the glass body. This gap is usually covered up by a silicone ring which is a flexible and rubberlike plastic material.

Using information from Fig. 8A.2, explain why the gap is necessary. [2]

From Fig. 8A.2, stainless steel expands about 5.2 times more than borosilicate glass for the same temperature rise / steel has a higher thermal expansion coefficient. [1]
A gap is necessary so that the kettle will not crack / allow room for expansion. [1]

(c) Given that the specific heat capacity of water = 4200 J kg^{-1} K^{-1} and the specific latent heat of vaporisation of water = 2.3 X 10^6 J kg^{-1}.

(i) Calculate the amount of energy needed to raise the temperature of 1.5 kg of water from 30.0 °C to 100.0 °C. [2]

Q = (1.5)(4200)(100.0 - 30.0) [1]
= 441000
= 440 kJ (to 2 s.f.) [1]

(ii) The kettle switches off automatically 1.0 minute after the water has reached its boiling point. Calculate the mass of water boiled away in this time. [3]

Power = Energy / Time
Energy = Power X Time = 1500 W X 60 s [1]
= 90 000 J
Latent heat = m X l_v
90 000 = m X 2.3 X 10^6 [1]
m = 0.039 kg (to 2 s.f.) [1]

OR

8B) Fig. 8B.1 shows an experimental setup which can be used as a thermometer. The narrow tube which emerges from the top of the flask shows the water level at the room temperature of 28.0 °C. Fig. 8B.2 shows the height of the water level above point **X** of the flask, *h*, when it was immersed in a trough of water at different temperatures, *T*.

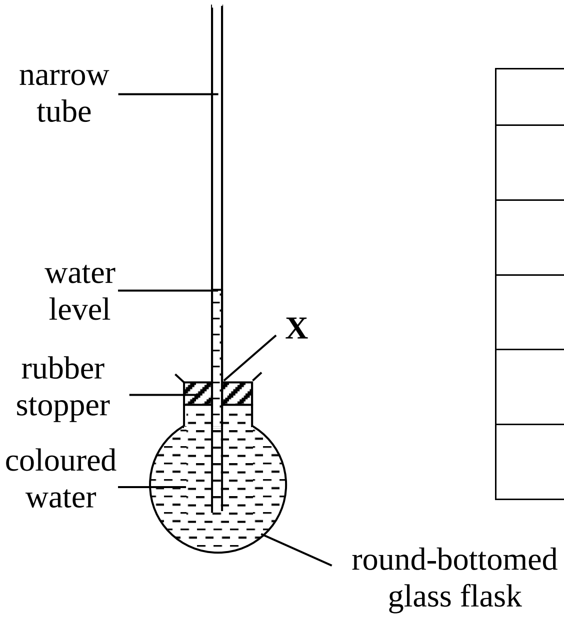


Fig. 8B.1

h / cm	*T* / °C
12.5	20.0
14.5	28.0
17.5	40.0
20.5	52.0
22.5	60.0

Fig. 8B.2

(a) (i) State the thermometric property when the setup in Fig. 8B.1 was used as a thermometer. [1]

Height of water level above point **X** of the flask
(Length / Volume (assume uniform cross-section) / Expansion accepted.)

(ii) Name a suitable apparatus which can be used to measure the thermometric property stated in (a)(i). [1]

Metre rule / Half-metre rule / Ruler (Only these accepted.)

(b) (i) Complete the table in Fig. 8B.2. [1]
(ii) State the assumption made for the computation in (b)(i). [1]

The expansion of water in the temperature range is linear / uniform.

(c) From room temperature, the round-bottomed glass flask was fully immersed in a trough of water at 15 °C. The measurement of *h* was taken when the water level was steady.

(i) Why was it necessary to measure *h* only when the water level was steady? [1]

When the water level was steady, the water in the flask had reached <u>thermal equilibrium</u> with the water in the trough.

(ii) State the process by which thermal energy was transferred through the glass flask. [1]

Conduction

(iii) Explain, in molecular terms, how the process in (c)(ii) transferred thermal energy through the glass flask. [3]

<u>Mechanism: Molecular vibration</u> (Electron diffusion is not acceptable)
The particles near the **<u>inner side</u>** of the flask **<u>collide</u>** <u>with less energetic</u> **<u>neighbouring particles</u>** [1] and pass some energy to them.

Process continues until energy is passed to the particles at the **<u>outer side</u>** **<u>[1: direction of energy flow]</u>** of the glass and they **<u>vibrate faster or gain kinetic energy</u>** <u>[1]</u>.

(d) The round-bottomed flask was partially filled with air and the same coloured water as shown in Fig. 8B.3.

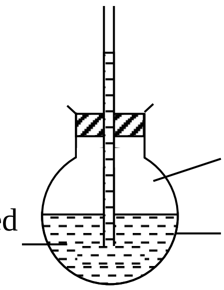


Fig. 8B.3

Given all other equipment and conditions remain the same, state one change in the characteristic of this new thermometer. [1]

The new thermometer is more responsive / more sensitive / has a smaller range.

~ ~ ~ END OF PAPER ~ ~ ~