Thinking Frameworks to Guide Physics Problem Solving

Problem Type	Thinking Framework	Steps	Common Errors
Graph Interpretation & Sketching	AUSGAI	• Identify **AXES**	• **AXES** are mixed up
		• Use correct powers and **UNITS** of quantities for calculation	• Wrong powers of quantities • Wrong **UNITS** of quantities
		• Interpret/draw **SHAPE** based on equation/theory	• Incorrect interpretation/drawing of **SHAPE** based on equation/theory
		• Interpret/Calculate **GRADIENT**	• Incorrect interpretation/calculation of **GRADIENT** (eg points chosen too near)
		• Interpret/Calculate **AREA UNDER GRAPH**	• Incorrect interpretation/calculation of **AREA UNDER GRAPH**
		• Interpret/Calculate **INTERCEPTS**	• Incorrect interpretation/calculation of **INTERCEPTS**
Quantitative Problem Solving (especially cross-topic questions)	GRILS	• Identify **GIVEN QUANTITIES** (including units conversion)	• Incorrect use of **GIVEN QUANTITIES** (including units conversion)
		• Identify **REQUIRED QUANTITY**	• Incorrect identification of **REQUIRED QUANTITY**
		• Think of key **IDEA** (Principle) to solve problem	• Incorrect application/presentation of key **IDEA** (Principle)
		• Make **LINKS** from REQUIRED QUANTITY to GIVEN QUANTITIES with presentation of o Principle o Formulae o Substitution o Calculation	• Incorrect **LINKS** from REQUIRED QUANTITY to GIVEN QUANTITIES • No/Insufficient presentation of principle, formulae, substitution OR calculation
		• Check answer is **SENSIBLE** with correct rounding, significant figures and units.	• Answer is not **SENSIBLE** (eg should be positive/negative, too large/small, illogical with earlier/later parts of question) • Incorrect rounding, significant figures OR units.

Qualitative Explanation	PRC	• Identify **PRINCIPLE**	• Incorrect identification of **PRINCIPLE**
		• Develop clear **REASONING** with good linkages between points	• Unclear **REASONING** with poor linkages between points
		• State **CONCLUSION** that links back to question	• Incorrect **CONCLUSION** that does not link back to question

Cedar Girls' School

For Examiner's Use

9 Read the following extract about tower running.

"Swissôtel Vertical Marathon was held on 25 Nov 2018 and in the event, participants were expected to run up 1,336 steps over 73 storeys (spanning a vertical distance of 201 m) in the shortest time possible. Soaring at a height of 226 metres as one of Southeast Asia's tallest hotel, Swissôtel The Stamford has been the site for Asia's pioneer and most challenging tower running event since its inauguration in 1987.

Tower running is a sport that involves running up tall man-made structures. Usually, the race will take place on the internal staircase of skyscrapers, including Willis Tower in Chicago, Eureka Tower in Melbourne, Taipei 101 in Taipei, Menara Tower in Kuala Lumpur, and Swissôtel in Singapore.

Similar to preparations for any sports events, runners have to consume a high-carb diet (food rich in carbohydrates) one day before the competition. A high-carb diet is defined as a diet in which carbohydrates provides for least 60% of the energy required for a person's daily activities. A commonly used unit in measuring the amount of energy in food is the calorie. One calorie is also defined as the amount of energy required to raise the temperature of 1.0 gram of water by 1.0 degree Celsius. Typically, 1.0 gram of carbohydrates contains 4000 calories of energy."

Adapted from Challenge yourself with Vertical Marathon, URAH Singapore, 2013. Retrieved August 12, 2020, from https://urah.com.sg/article/challenge-yourself-with-vertical-marathon

In the calculations below, you may assume that:
specific heat capacity of water is 4200 J kg^{-1} $°C^{-1}$.

(a) Calculate the amount of energy that one calorie of food contains. Present your answer in the S.I. unit for energy.

energy = ... [1]

For Examiner's Use

(b) Determine the minimum amount of work done for a person with a mass of 50 kg to overcome his weight to complete the Swissôtel Vertical Marathon.

minimum work done = ... [2]

(c) Based on the answer in **(b)**, calculate the minimum mass of carbohydrates that a person on a high-carb diet needs in preparation for the Swissôtel Vertical Marathon.

minimum mass = ... [2]

CGS

(d) A student, whose mass is unknown, prepares for the Swissôtel Vertical Marathon. He carries out an experiment to measure the average power he produces as he runs up the stairs. Using the staircase in his school, he runs up a flight of stairs as shown in Fig. 9.1.

For Examiner's Use

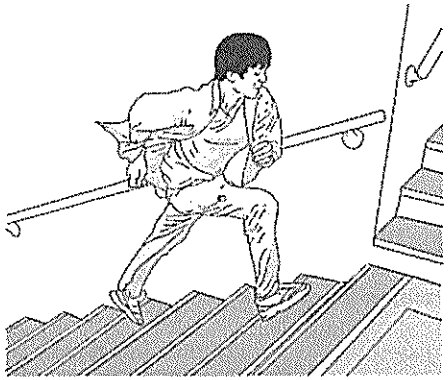

Fig 9.1

Describe a possible experiment for the student to achieve his objective. In your description, include the type(s) of data that the student has to collect, measuring instrument(s) the student has to use to collect the data, and formulae (if any) for the student to calculate the average power he produces.

.....

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..... [4]

(e) From the experiment, the student found out that his mass is 50 kg and the average power he produces is 48 W. Determine the time that he will take for the Swissôtel Vertical Marathon.

For Examiner's Use

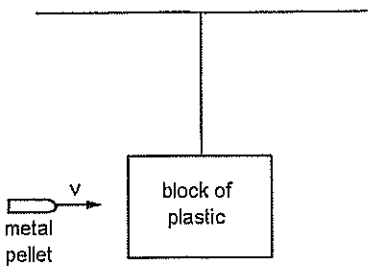
time taken = ... [1]

Hwa Chong Institution
Preliminary Examinations

9. In an experiment, different sized metal pellets are fired from an air rifle towards an 8.0 kg block of plastic suspended from the top of a ceiling.

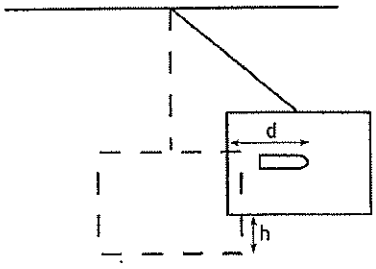
Fig 9.1 shows the initial position of the block of plastic.

Fig 9.2 shows how it is displaced when the pellet hits the block.



BEFORE

Fig 9.1



AFTER

Fig 9.2

Table 9.1 shows the information obtained from the experiment.

Table 9.1

mass of pellet, m (kg)	speed of pellet just before it hits plastic block, v (m/s)	depth of penetration by pellet, d (m)	time taken for pellet to come to a stop, t (s)	maximum increase in height of plastic block, h (m)
0.050	40	0.15	0.025	0.348
0.025	56	0.12	0.020	0.292
0.020	62	0.11	0.018	0.274

Take the gravitational field strength g to be 10 N/kg.

(a) Calculate the kinetic energy of the 0.025 kg pellet just before it hits the block of plastic.

kinetic energy = ... [2]

(b) (i) Calculate the deceleration of the 0.025 kg pellet.

deceleration = ... [2]

(ii) Hence or otherwise, calculate the resistive force acting on the 0.025 kg pellet.

resistive force = ... [2]

[Turn over

(c) Calculate the work done against friction by the 0.025 kg pellet.

work done = ... [2]

(d) Show that there is a discrepancy between the experimental and theoretical values for the increase in height of the plastic block.

[2]

南僑中學

NAN CHIAU HIGH SCHOOL

PRELIMINARY EXAMINATION

10 Wind power can be used for the generation of electric power. **Fig. 10.1** illustrates one particular type of wind turbine. The wind causes the rotor blades to turn and these blades drive an electric generator.
Some technical information of the wind turbine is given in **Fig. 10.2** and **Fig. 10.3**.

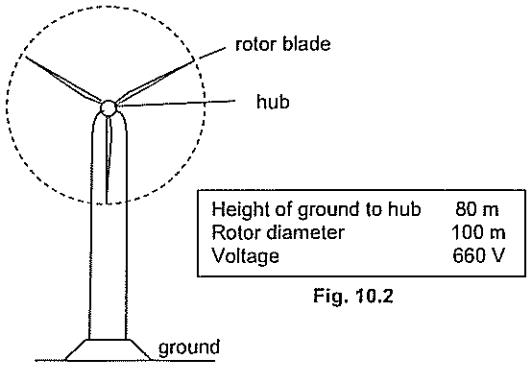


Fig. 10.1

Height of ground to hub	80 m
Rotor diameter	100 m
Voltage	660 V

Fig. 10.2

wind speed v / ms^{-1}	output power / kW
0-3	0
4	79
5	254
6	458
7	740
8	1117
9	1595
10	2103
11	2505
12	2870
13	3032
14	3034
15 to 20	3028
21 and more	0

Fig. 10.3

(a) Determine the minimum height of the tip of a rotor blade above ground level. [1]

(b) Suggest why the output power is zero when the speed is 21 ms^{-1} or more. [1]

(c) Air of density ρ, 1.25 kgm^{-3} and speed v is incident normally on a rotor of radius r.
The kinetic energy E of the air incident per unit time on the rotor is given by

$$E/t = 0.5\,\pi r^2 v^3 \rho.$$

Calculate, for the wind turbine operating at **maximum output power**, the

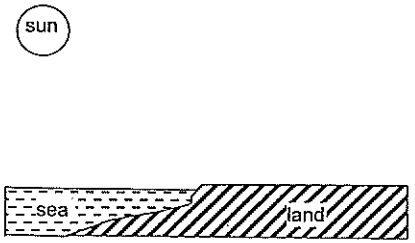
(i) kinetic energy of air incident per second on the rotor, [1]

(ii) overall efficiency of generation of electric power. [2]

(c) (iii) Suggest why the efficiency of a wind turbine is not 100%. [1]

(d) In the day, the temperature of the land rises faster than that of the sea and this causes sea breeze.

Explain with the aid of the given diagram how wind (sea breeze) is formed in the day. [2]



(e) State and explain one safety precaution that can protect the wind tower from lightning strike. [2]

NCHS

13 EITHER

Following the excitement of green building, zero energy building (ZEB) has become the next challenge for architects nowadays. According to its name, the building should consume zero energy that leads to reducing carbon emission and minimizing the use of fossil fuel i.e. energy produced by a building is equal to the energy consumed by the building. To reduce the energy consumption for lighting, passive daylighting strategies which promote the quantity and uniform distribution of daylight throughout a building are used. The strategies collect natural light and reflect it into darker areas of the building.

One strategy is the installation of solar tubes on the roofs of buildings. A solar tube is essentially a tube that reflects daylight into spaces that are otherwise dark interior spaces. Fig. 13.1 shows how solar tubes may be placed to light up buildings.

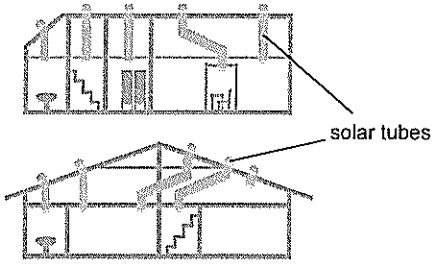


Fig. 13.1

A solar tube is made up of three main parts: the light collector on the roof, a transfer system which brings the light from outside into the building and the light diffuser which is on the ceiling. This is shown in Fig. 13.2.

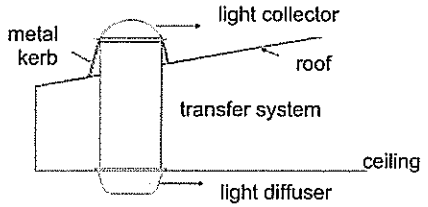


Fig. 13.2

(a) Explain why a dome-shape light collector is more efficient compared to a flat light collector.

_____

_____

_____ [1]

(b) Fig. 13.3 and Fig. 13.4 below show scaled diagrams of a flat and a hemispherical light collector respectively. Two parallel rays of the light strike the light collectors.

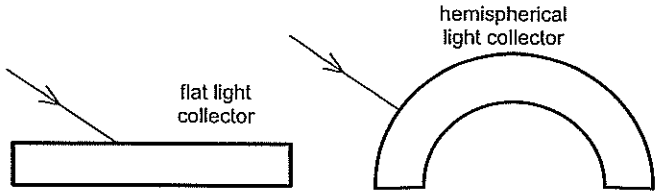


Fig. 13.3

Fig. 13.4

(i) From each figure, determine the angles of incidence.

angle of incidence for flat light collector = _____

angle of incidence for hemispherical light collector = _____ [1]

(ii) Sketch the path of rays until it emerges on the opposite side of the light collector.

[2]

(c) The transfer system is a tube with a highly reflective coating on the inside. Light emerging from the light collector will strike the side of the tube and is reflected multiple times until it reaches the light diffuser.

(i) Fig. 13.5 below shows a section of the transfer system tube. Complete the path of the ray of light shown until it emerges from the tube.

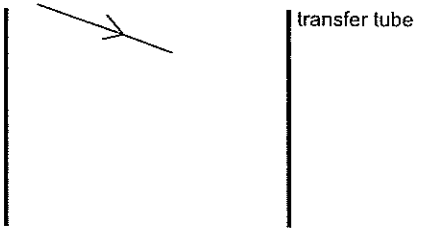


Fig. 13.5

[2]

MYGH

(ii) Explain how the number of reflections in the transfer tube affects the amount of light that is transmitted through a solar tube.

[2]

(d) The light diffuser can be made applying a film of acrylic to a sheet of glass at the bottom of the solar tube as shown in Fig. 13.6.

Fig. 13.6

Explain how the film works to diffuse the light?

[2]

OR

Parking lot sensors can be found in many large carparks. They detect and report parking space occupancy, thus enabling active parking lot management features, such as search, navigation and reservation.
One type of sensor makes use of an ultrasonic system. The sensor has an ultrasound transmitter and a receiver. The sensor is connected to an indicator light which shows red if a parking lot is occupied and green if it is available.

Fig. 13.7 shows single space sensors and indicator lights that are mounted above parking lots.

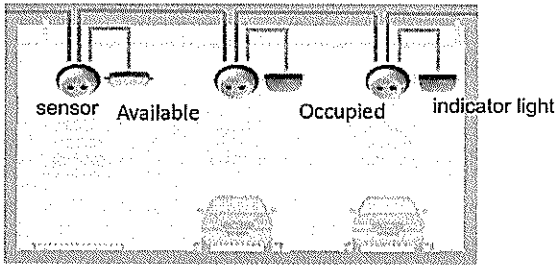


Fig. 13.7

The transmitter sends a pulse of ultrasound downwards and the receiver detects the ultrasound after it is reflected up. The reference value is height of the sensor from the parking lot floor and the tolerance value allows for changes in the reference value e.g. due to unevenness on the floor. This is shown in Fig. 13.8.

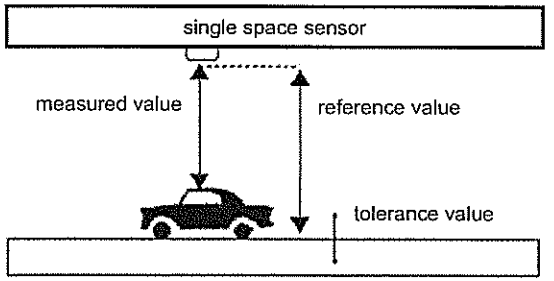


Fig. 13.8

(a) Apart from being inaudible to humans, suggest another advantage of using ultrasound for such sensors.

[1]

(b) Ultrasound signals are emitted from the transmitter every 50 ms. Fig. 13.9 shows the emitted signals from the transmitter and their reflected signals over a period of time for one of the parking lots.

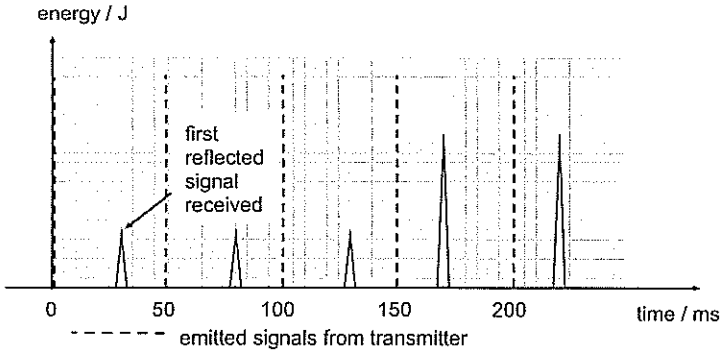


Fig. 13.9

(i) State the time at which the receiver first detects a vehicle in the lot.

time vehicle is first detected = _____ [1]

(ii) Explain the difference(s) in the received signals when the parking lot is vacant and when it is occupied.

_____

_____

_____

_____

_____ [2]

(iii) The speed of sound in air is 340 m s^{-1} and the frequency of the ultrasound emitted by the transmitter is 25 kHz.
Calculate the distance between the top of the vehicle and the sensor.

distance = _____ [2]

(iv) If an ultrasound of a higher frequency is transmitted by the sensor, state how the reference value is affected.

_____

_____ [1]

(v) If the system is now set up underwater, explain one change in the graph shown in Fig. 13.6.

_____

_____

_____

_____

_____ [2]

(c) Suggest a reason why this ultrasound system may not be suitable for an open air carpark, even if the set-up is weatherproof.

_____

_____ [1]

End

Section B

Answer **all** the questions in this section.

Answer only one of the two alternative questions in **Question 12.**

10 **(a)** The displacement-distance graph of a wave in a string at an instant in time is shown in Fig. 10.1.

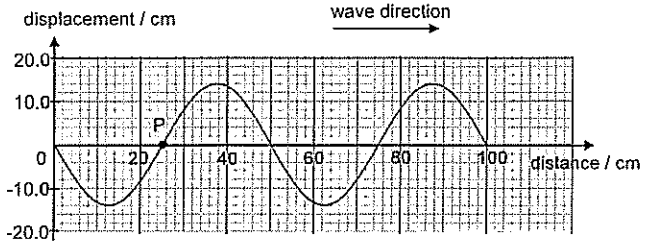


Fig. 10.1

(i) Determine the wavelength of the wave.

wavelength = ... [1]

(ii) The wave has a frequency of 2.0 Hz.

Calculate the distance travelled by the wave in 0.060 s.

distance = ... [2]

(iii) On Fig. 10.1, draw an arrow to show the direction of motion of particle P in the next instant of time. [1]

(iv) Estimate the displacement of particle P after 0.060 s.

displacement = ... [1]

(b) Fig. 10.2 shows an ultrasound transmitter and receiver placed in contact with the skin.

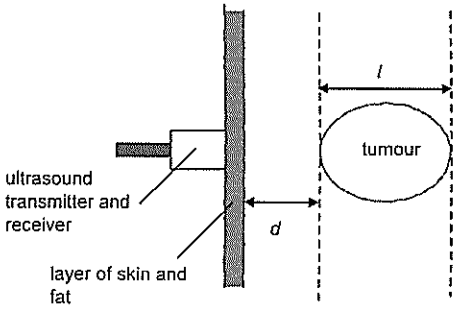


Fig. 10.2

The scan can determine the depth, *d* of a tumour below the skin and the length of the tumour, *l*.

On Fig, 10.3, the strength of the reflected ultrasound pulses is plotted against time *t* where *t* is the time taken for the ultrasound receiver to receive the pulse after being transmitted.

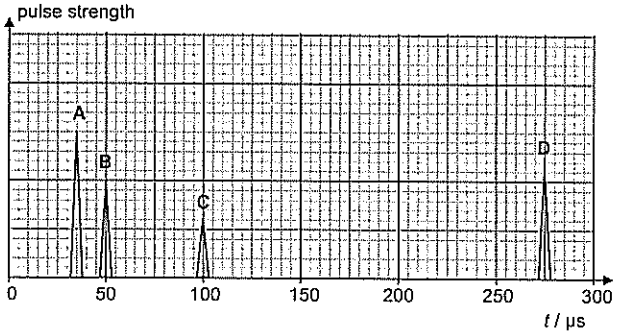


Fig. 10.3

(i) Suggest a reason why a layer of gel is applied between the ultrasound transmitter/receiver and the skin during the scan.

.....

..... [1]

VS

(ii) Indicate with a cross X on Fig. 10.4 the origin of the reflected pulse D. [1]

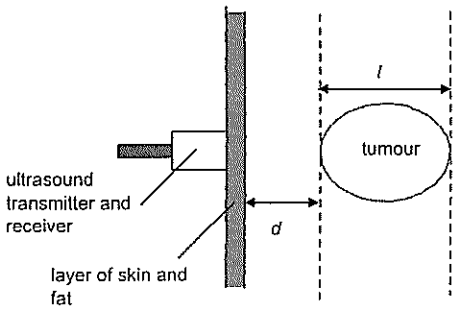


Fig. 10.4

(iii) The average speed of the ultrasound in human tissue and muscle is 1.5×10^3 m / s.

Using data from Fig. 10.3, determine length *l* of the tumour.

l = ... [2]

(iv) State one advantage of using ultrasound as opposed to using X-rays in medical diagnosis.

.....

..... [1]

Anglo-Chinese School (Barker Road)

PRELIMINARY EXAMINATION

11 In many countries, where the average outdoor temperature can vary from -3°C to 19°C, solar energy is used for heating up the interior of the house. Solar energy is absorbed by cool water running through coiled pipes located on rooftops as shown in Fig. 11.1.

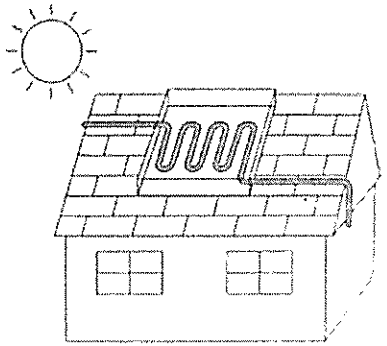


Fig. 11.1

The warm water is then stored in an insulated water tank as shown in Fig. 11.2.

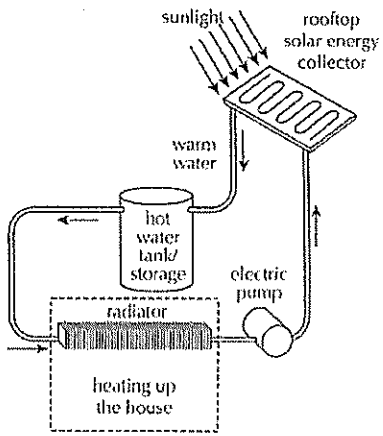


Fig. 11.2

In passing through the radiator, the water in the pipe will reach the same temperature as the required indoor temperature in the house. After moving through the electrical pump, the water will reach the same temperature as the outdoor temperature.

Data relevant to the usage of the heating system is given in the box.

Temperature of warm water: 45°C
Specific heat capacity of water: 4.2×10^3 J/ kg°C
Power of the rooftop solar energy collector: 12 kW
Average thermal energy required to maintain indoor temperature of 25°C for 24 h : 200 MJ

Fig. 11.3 shows the average outdoor temperature and average daily sunshine duration in France and Fiji for the month for the month of May.

	France	Fiji
average outdoor temperature / °C	14	19
average daily sunshine duration / hr	7.5	4.0

Fig. 11.3

ACSB

(a) The heating system is installed in a house in France.

(i) Determine the average mass of warm water required daily to maintain the indoor temperature at 25 °C.

average mass of warm water = ... [2]

(ii) Calculate the total solar energy required to heat up the cool water daily to maintain the room temperature at 25 °C.

total solar energy = ... [2]

(iii) Calculate the time needed by the solar collector to absorb the amount of solar energy calculated in (a)(ii).

time = ... [2]

(b) With reference to Fig 11.3, explain why the heating system is not able to maintain the indoor temperature at 25 °C for Fiji.

.....

.....

.....

.....

..... [2]

(c) Suggest a material for making the coiled water pipes at the rooftop and explain the reason for your choice.

.....

.....

..... [2]

SECTION B (30 marks)

Answer **all** questions in this section.
Answer only one of the two alternative questions in **Question 13.**

11 Fig. 11.1 shows the arrangement used to measure the temperature rise of a piece of lead struck by an air-gun lead pellet.

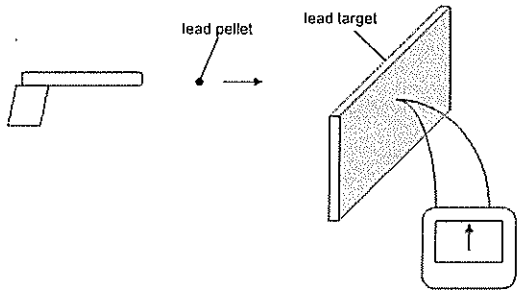


Fig. 11.1

The thermometer consists of a thermocouple whose junction is embedded in the lead. When the temperature of the junction is raised, a deflection is observed on the galvanometer. After the lead pellet is fired into the lead target, the results and data are given below.

Mass of lead target = 39.5 g
Mass of lead pellet = 0.5 g
Deflection on galvanometer = 8 divisions
Specific heat capacity of lead = 130 J / (kg °C)
Galvanometer sensitivity = 10 divisions /°C

(a) Write down the thermometric property of the thermometer and state an assumption on using this property with respect to temperature measurements.

thermometric property : _____

assumption : _____

_____ [2]

(b) Explain what is meant by specific heat capacity of lead is 130 J / (kg °C).

_____

_____ [1]

[Turn Over

(c) **(i)** Determine the temperature rise of the lead target.

temperature rise = _____ [1]

(ii) Hence, calculate the thermal energy gained by the lead target.

thermal energy = _____ [2]

(d) The lead target with the lead pellet embedded, is then detached from the thermometer and immersed into icy water with 20 g of ice and 100 g of water at 25.0 °C. The initial temperature of the lead target and the lead pellet is 40.0 °C.

The specific heat capacity of water is 4200 J / (kg °C).
The specific latent heat of fusion of ice is 3.4×10^5 J / kg.

(i) Assuming all the ice melted in the process, calculate the final temperature of the lead target with the pellet embedded.

final temperature = _____ [3]

(ii) State an assumption you made in the above calculation.

_____

_____ [1]

PLMGS

PRESBYTERIAN HIGH SCHOOL

9 (a) When a spacecraft returns to Earth from space, it must first re-enter the atmosphere. A high speed spacecraft has a very large amount of kinetic energy. As it is slowed down, the kinetic energy is converted into thermal energy. The temperature rise during re-entry is a major problem for spacecraft designers - the astronauts inside must not be cooked!

During the re-entry of the American Mercury capsules, the air outside the capsule reach a temperature of 5260°C and turned orange. The outside of the capsule itself reached a temperature of 1648°C. A special resin, on a fiberglass screen, was attached to the surface. The resin boiled and evaporated during this re-entry journey.

State and explain the function of this special resin coating on the surface of the American Mercury capsules.

.....

.....

..... [3]

(b) In Fig. 9.1, the Space shuttle uses special silica tiles to protect it. The bottom and the leading edge are covered with glossy black tiles and a black reinforced carbon material covers the nose and wing leading edges.

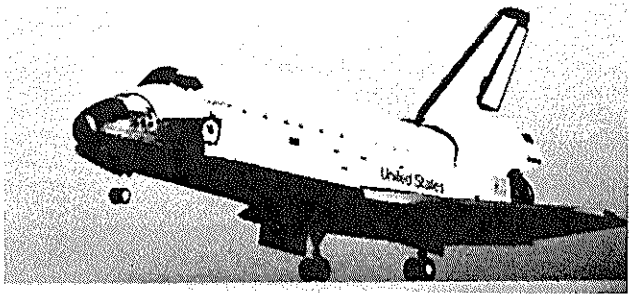


Fig. 9.1

Explain how the following properties of the material used to cover the outer surface of a spacecraft keep the insides of the space shuttle cool.

(i) colour;

.....

..... [1]

(ii) specific heat capacity;

.....

.....

.....

..... [2]

(iii) thermal conductivity.

.....

..... [1]

(c) During the launch of the NASA space shuttle, the used rocket thruster will be ejected just before the space shuttle exits the atmospheric layer.

An aluminium section of a used rocket thruster has a mass of 1 kg. It returns to Earth at a speed of 5000 m/s. The boiling point of aluminium is 2467 °C.

(i) Assume that all the kinetic energy of the rocket thruster is converted into thermal energy as it enters the atmosphere.

Find the temperature rise of the section given that the specific heat capacity of aluminium is 900 J/(kg°C).

temperature rise = ... [2]

(ii) Explain why it is not likely for such small sections of the rocket thruster to be found on the surface of the Earth.

.....

..... [1]

PHS

SINGAPORE CHINESE GIRLS' SCHOOL
PRELIMINARY EXAMINATION

9 Read the passage carefully and answer the questions that follow.

The microwave oven is now commonly used in kitchens to quickly heat up pre-prepared and fresh food. It produces microwave radiation of frequency 2500 MHz that is absorbed by water molecules. The water molecules have charge distributions which are not symmetric. When the electromagnetic field in the microwave radiation is incident on them, the water molecules increase in vibration. The microwaves can only penetrate a short distance inside the food.

The typical power in the microwave beam is 750 W. Over each distance of 3 mm, the power available from the microwave decreases by 60%.

(a) Explain what is meant by a *frequency of 2500 MHz*. [1]

.....

.....

(b) Calculate the wavelength of the microwave used in the microwave oven. [2]
Take the speed of the microwave as 3.0×10^8 m/s.

Wavelength of the microwave = ...

(c) Use information in the passage to sketch a graph showing how the power available from the microwave varies with depth. Plot points at depths of 0, 3, and 6 mm on Fig. 9.1. Draw the line of best fit for these plotted points. [3]

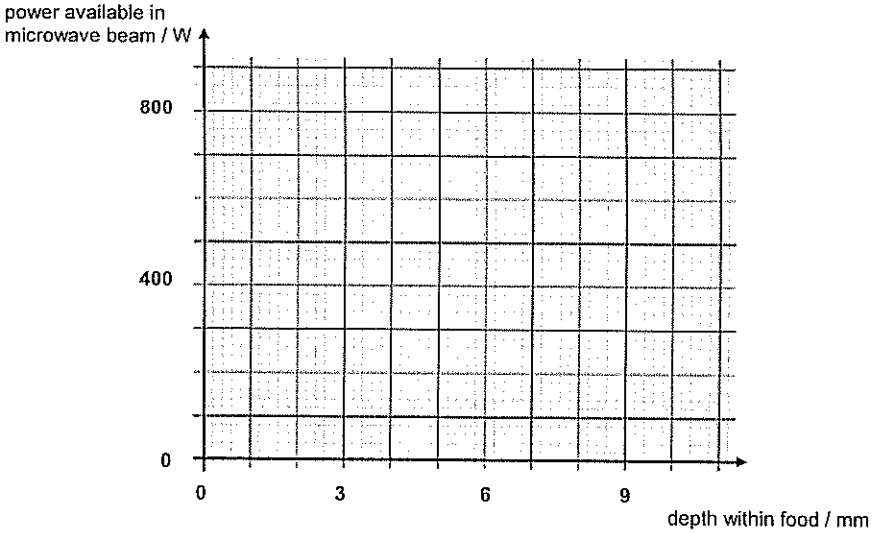


Fig. 9.1

(d) Estimate, from your graph drawn in (c), the power available at depth of 5 mm. [1]

Power available = ...

(e) Estimate the minimum time it will take a 750 W microwave oven to thaw 0.25 kg of frozen soup. The soup is initially at -18 °C and is to be just turned into liquid at 0 °C. The soup can be assumed to be made entirely of water. Take the specific heat capacity of ice as 2100 J/(kg °C) and the specific latent heat of fusion of ice as 340 000 J/kg. [3]

Minimum time to thaw the frozen soup = ...

SCGS

CANDIDATE NAME

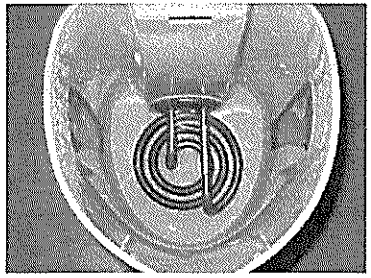
CLASS

INDEX NUMBER

Section B			
Q10	Q11	Q12E	Q12O

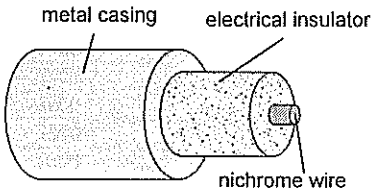
Section B (30 marks)
Answer all questions in this section.
Answer only one of two alternative questions in **Question 12.**

10 Fig. 10.1 shows a heating element of a 1200 W kettle. The heating element is near to the base of the kettle. Fig. 10.2 shows the different components of the heating element. The nichrome wire is insulated by an electrical insulator and enclosed by a metal casing.



https://commons.wikimedia.org/wiki/File:Filament_in_an_electric_kettle.JPG

Fig. 10.1



https://en.wikipedia.org/wiki/Heating_element#/media/File:Tubular_Electric_Heater.svg

Fig. 10.2

(a) Explain why the heating element is designed to be near the base of the kettle.

.....

.....

.....[2]

(b) Explain how the following features ensure water in the kettle boils quickly.

(i) A lid for the kettle.

.....

.....[1]

(ii) The casing of the heating element is made of metal.

.....

.....[1]

(c) Jane wants to make herself a cup of iced milo. She first boils 500 g of water using the 1200 W kettle to prepare a cup of hot milo. She then adds ice to decrease the temperature of the hot milo. The specific heat capacity of water is 4200 J/kgK.

(i) Explain what is meant by 'the specific heat capacity of water is 4200 J/kgK'.

.....

.....[1]

(ii) Determine the time taken for the temperature of the 500 g of water to increase from 30°C to 100°C.

time = ... [2]

(iii) Jane wants to decrease the temperature of the hot milo from 80°C to 15°C. Determine the amount of ice at 0°C that needs to be added.
[Heat capacity of hot milo = 900 J/K and the specific latent heat of fusion of ice = 336 kJ/kg]

mass = ... [2]

SJI

(iv) In reality, the mass of ice that needs to be added to the milo in order for the temperature to reach 15°C is less than the mass calculated in c(iii). Explain why.

.....

.....[1]

11 A temperature activated appliance makes use of an NTC thermistor to switch on the appliance when the temperature falls below a certain level. Table 11.1 shows how the resistance of the NTC thermistor varies with temperature.

Temperature/°C	Resistance/Ω
14	4960
16	4530
18	4190
20	3850
22	3520
24	3200
26	2900
28	2700
30	2500
32	2300
34	2100
36	1950
38	1800
40	1650
42	1520
44	1410

Table 11.1

(a) Using the data from Table 11.1, describe the relationship between the resistance of the thermistor and its temperature over the range shown.

.....

.....

..... [2]

Section B (30 marks)

Answer **all** the questions in this section.
Answer only one of the two alternative questions in **Question 12.**

10 Fig. 10.1 shows the electromagnet made by a student.

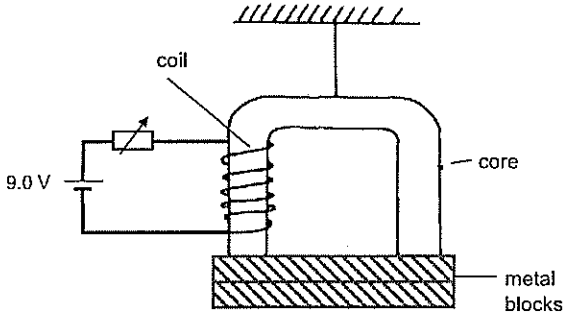


Fig. 10.1

The student uses four different materials A, B, C and D as the core of the electromagnet. Table 10.1 shows the information about the four materials.

Table 10.1

Material	Relative Permeability	Density / gcm^{-3}
A	1	2.70
B	300	7.85
C	5000	7.87
D	8000	8.70

The relative permeability of a material is the measure of the ease with which magnetism can be induced in the presence of an external magnetic field. The higher the number, the easier the material is magnetised.

(a) On Fig. 10.1, indicate the North pole of the electromagnet with a letter "N". [1]

(b) State and explain which two materials from Table 10.1 are suitable to be used as the core of the electromagnet.

.....

.....

..... [2]

(c) When the correct material is used as the core, the electromagnet exerts an upward magnetic force *F* on the metal blocks and attracts them.

Describe the other force that is part of the action-reaction pair with *F*, and state the body it acts on.

.....

..... [2]

(d) On Fig. 10.2, draw three field lines to show the magnetic field pattern for each of the electromagnet when materials A and D are used as the core.

You do not need to indicate the direction of the magnetic field.

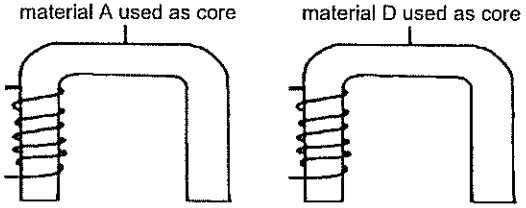


Fig. 10.2 [2]

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(e) Fig 10.3 shows how the weight of blocks lifted by the electromagnet in Fig. 10.1 varies with the current in the coil.

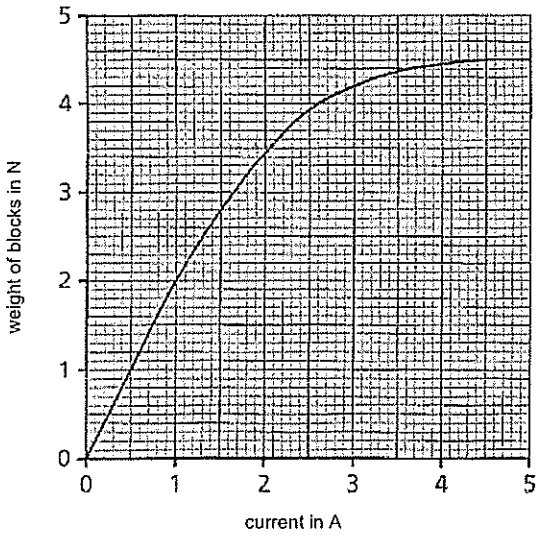

Fig. 10.3

(i) Determine the minimum current required to lift blocks of weight of 3.0 N.

minimum current = ... [1]

(ii) The student decides to increase the electromotive force of the battery to lift blocks of weight of 6.0 N.

Explain whether the student's method will work.

.....

.....

..... [2]

Section B

Answer all **three** questions in this section.
The last question is in the form of an **Either/Or** question. Only one part should be answered.

10 Air is a non-conductor of electricity. However, electricity can still flow through air in the form of electrical discharge if the p.d. (potential difference) across it is large enough.

An experiment is conducted with p.d. applied across two conducting spheres at a length *d* apart as shown in Fig. 10.1.

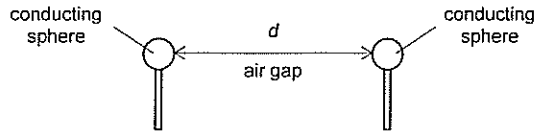

Fig. 10.1

(a) When *d* is set at 0.5 cm, the p.d. slowly increases until electrical discharge occurs from one sphere to the other. The p.d. required is measured as 20 kV.

The experiment is then repeated with *d* = 1.0 cm, 1.5 cm, 2.0 cm and 2.5 cm.

Fig. 10.2 shows a best fit curve of how the p.d. required varies with *d*.

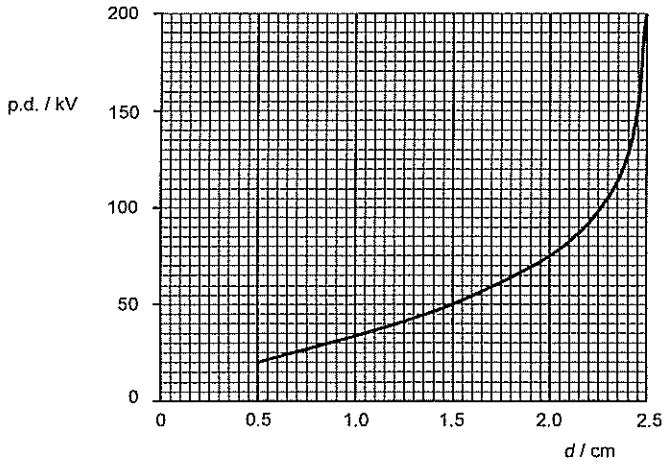

Fig. 10.2

(i) Using Fig. 10.2, describe how the p.d. required varies with *d*.

.....

.....

.....[2]

(ii) Using Fig. 10.2, explain why it is dangerous for people to switch on appliances that operate at high voltages above 20 kV directly.

.....

.....[1]

(iii) Suggest and explain the value of p.d. required when *d* = 0.0 cm.

.....

..... [1]

(b) Once a discharge occurs, p.d. across the spheres will be reduced to 0 immediately to prevent continuous discharge.

The amount of current I and duration of each discharge *t* are measured and recorded in Fig. 10.3 below.

d / cm	I / A	*t* / s
0.5	0.5	0.05
1.0	2.0	0.25
1.5	4.0	0.30
2.0	12.0	0.45
2.5	30.0	0.70

Fig. 10.3

(i) Using Fig. 10.3, calculate the total amount of charges that had flowed through in the process of collecting the five sets of results.

charges = ... [2]

HIHS

Using Fig. 10.2 and 10.3,

(ii) Calculate the total energy used in the experiment for p.d. of 50 kV and above.

total energy = ... [2]

(iii) Hence, or otherwise, calculate the average power used for p.d. of 50 kV and above.

average power = ... [1]

(iv) Suggest a reason why the duration of discharge increases as d increases.

.....

.....

..... [1]

Section B

Answer all three questions in this section.

The last question is in the form of an either/or and only one of the alternatives should be attempted.

10 A student conducted an experiment to investigate how the thickness of a copper wire affects the potential difference across it. The set-up of his experiment is shown in Fig.10.1. The length of all the copper wires used is 0.050 m.

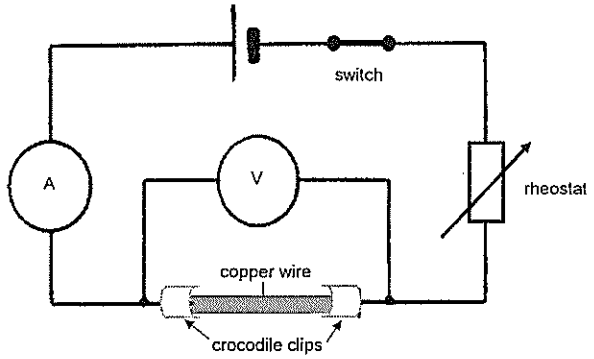

Fig. 10.1

(a) Each piece of copper wire is clamped, in turn, between two crocodile clips. When the ammeter reading is set to 2.0 A, the voltmeter reading is recorded. Fig. 10.2 shows the cross-sectional areas of the different copper wires and their corresponding voltmeter readings.

Wire	Cross-sectional area / m^2	Voltmeter reading / V
K	0.0020×10^{-6}	0.85
L	0.0040×10^{-6}	0.43
M	0.0080×10^{-6}	0.21
N	0.016×10^{-6}	0.11
O	0.032×10^{-6}	
P	0.064×10^{-6}	0.028

Fig. 10.2

(i) Explain the function of the rheostat in the circuit.

.....

.....[1]

(ii) State the relationship between the cross-sectional area of the wire and the potential difference across it.

.....

.....[1]

(iii) Explain how the data in Fig 10.2 suggest the relationship stated in **(ii)**.

.....

.....

.....

.....[2]

(iv) Using data from Fig 10.2, predict the voltmeter reading when wire O is connected to the circuit.

voltmeter reading = ... [2]

MSHS

(b) Another copper wire, P with a different cross-sectional area is cut into 3 pieces of identical length. Each piece has a resistance of 0.20 Ω. The wires are arranged in a circuit as shown in Fig 10.3.

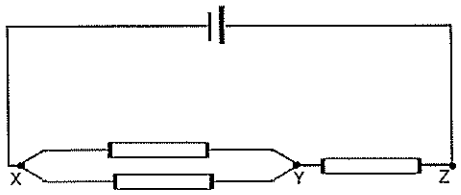

Fig. 10.3

(i) The potential difference across YZ is 1.0 V.
Calculate the e.m.f. of the cell.

e.m.f. = ...[2]

(ii) Another identical piece of wire similar to P is connected in parallel to XY.
Explain if there is any change to the potential difference across YZ.

.....

.....

.....

.....[2]

[Total: 10]