Anglo-Chinese Junior College

Physics Preliminary Examination
Higher 1

A Methodist Institution
(Founded 1886)

CANDIDATE NAME		CLASS	
CENTRE NUMBER	S 3 0 0 4	INDEX NUMBER	

PHYSICS **8866/02**

Paper 2 Structured questions

27 Aug 2014

2 hours

Candidates answer on the Question Paper
No additional Materials are required

READ THESE INSTRUCTIONS FIRST

Write your Name and Index number in the spaces provided at the boxes above and on all the work you hand in.
Write in dark blue or black pen.
You may use a soft pencil for any diagrams, graphs or rough working.
Do not use staples, paper clips, highlighters, glue or correction fluid.

Section A
Answer **all** questions.

Section B
Answer **any two** questions.

At the end of the examination, fasten all your work securely together.
The number of marks is given in brackets [ ] at the end of each question or part question.

For examiners' use only	
Section A	
1	/ 5
2	/ 6
3	/ 6
4	/ 8
5	/ 6
6	/ 9
Section B	
7	/ 20
8	/ 20
9	/ 20
Total	/ 80

For Examiner's Use

Data

speed of light in free space,	c	=	3.00×10^{8} m s^{-1}
elementary charge,	e	=	1.60×10^{-19} C
the Planck constant,	h	=	6.63×10^{-34} J s
unified atomic mass constant,	u	=	1.66×10^{-27} kg
rest mass of electron,	m_e	=	9.11×10^{-31} kg
rest mass of proton,	m_p	=	1.67×10^{-27} kg
acceleration of free fall,	g	=	9.81 m s^{-2}

Formulae

uniformly accelerated motion,	s	=	$ut + \frac{1}{2}at^2$
	v^2	=	$u^2 + 2as$
work done on/by a gas,	W	=	$p \Delta V$
hydrostatic pressure,	p	=	$\rho g h$
resistors in series,	R	=	$R_1 + R_2 + \ldots$
resistors in parallel,	$1/R$	=	$1/R_1 + 1/R_2 + \ldots$

For Examiner's Use

Section A

Answer **all** the questions in the spaces provided.

1 A ball of mass 9.0 kg is projected with a horizontal velocity of 1.50 m s^{-1} off a cliff as shown in Fig. 1.1. The ball travels a horizontal displacement of 0.50 m before it hits the ground. Assume the air resistance can be neglected.

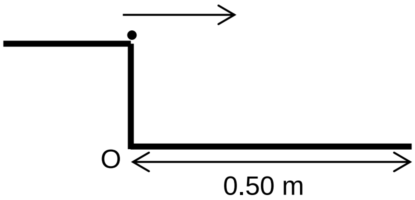

Fig. 1.1

(a) Show that the vertical velocity of the ball as it reaches the ground is 3.3 m s^{-1}.

[2]

(b) Determine the speed of the ball when it hits the ground.

Speed of ball = ……………… m s^{-1} [1]

(c) Hence or otherwise, on Fig. 1.2, sketch the variation with horizontal displacement the

(i) gravitational potential energy, and the [1]

(ii) kinetic energy of the ball. [1]

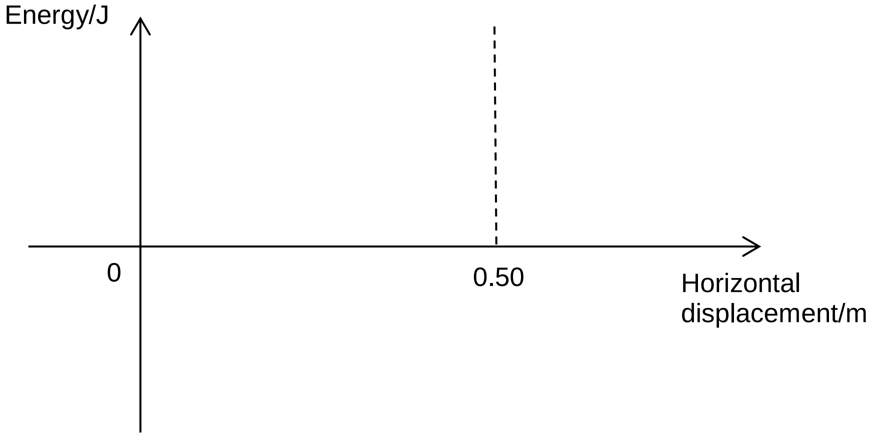

Fig. 1.2

For Examiner's Use

2 (a) State the two conditions for an object to be in equilibrium under a system of forces.

....

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....

....

.... [2]

(b) A student performs an experiment to investigate how the forces exerted on a bridge by its supports vary as a vehicle crosses the bridge.

She models the bridge and vehicle using a metre rule and a suspended mass.

Fig. 2.1 is a free-body force diagram for the rule. ***P*** and ***Q*** are the forces exerted by the supports;

W and ***V*** are equal to the weights of the rule and suspended mass respectively.

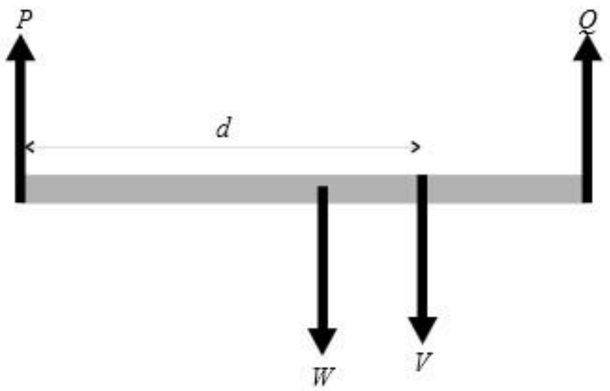


Fig. 2.1

Fig. 2.2 shows how ***Q*** was found to vary with the position *d*, of the mass.

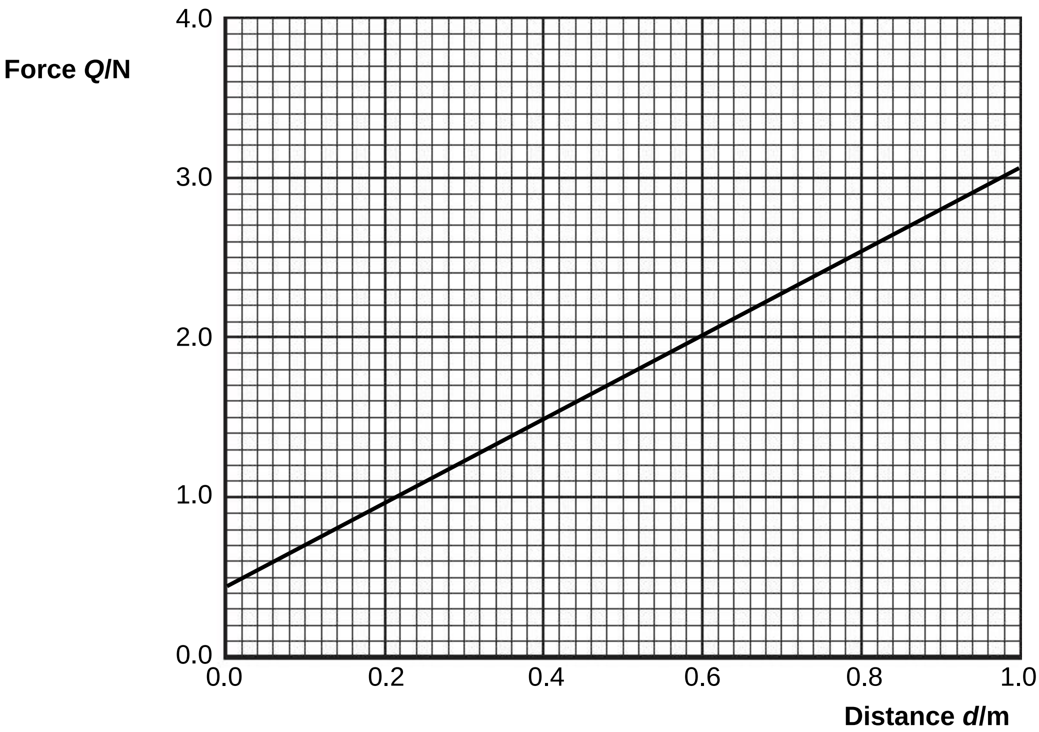


Fig. 2.2

For Examiner's Use

(i) Deduce that $Q = dV + 0.5\,W$.

....

....

.... [1]

(ii) Hence or otherwise, explain why force ***Q*** increases as distance increases.

....

....

.... [1]

(iii) Hence using the equation given in (i) and other information from the graph, determine the value of

1. ***V***

V = ... N [1]

2. ***W***

W = ... N [1]

3 A suspended spring of negligible mass that obeys Hooke's Law is stretched by a mass hung from one of its ends.

(a) Using the definition of work done, show that the elastic potential energy E stored in the spring can be represented as

$$E = \frac{1}{2} k\, x^2$$

[2]

For Examiner's Use

(b) The mass is displaced **downwards** from its equilibrium position and released.

Taking the gravitational potential energy of the spring-mass system **at the point of release** to be 0, sketch on Fig. 3 below the variation of

(i) elastic potential energy
(ii) gravitational potential energy
(iii) kinetic energy

with extension when the mass moves back to its equilibrium position.

Label your graphs clearly. [4]

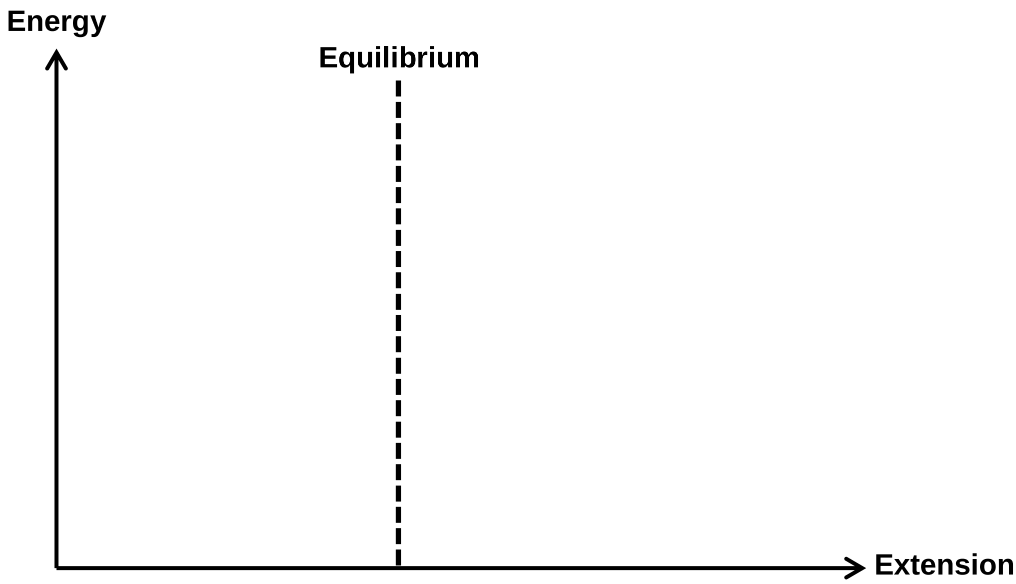


Fig. 3

4 (a) A variable resistor is used to control the current in a circuit, as shown in Fig. 4.1

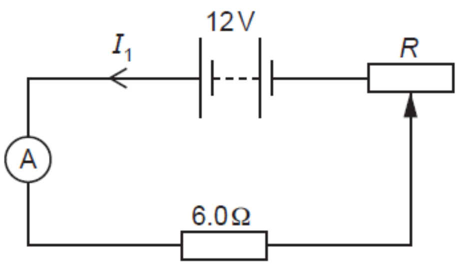


Fig. 4.1

The variable resistor is connected in series with a 12 V power supply of negligible internal resistance, an ammeter and a 6.0 Ω resistor. The resistance R of the variable resistor can be varied between 0 and 12 Ω.

(i) Show that the maximum possible current in the circuit is 2.0 A.

[1]

For Examiner's Use

(ii) Calculate the minimum possible current in the circuit.

minimum possible current = …………………. A [2]

(b) The variable resistor in (a) is now connected as shown in Fig. 4.2.

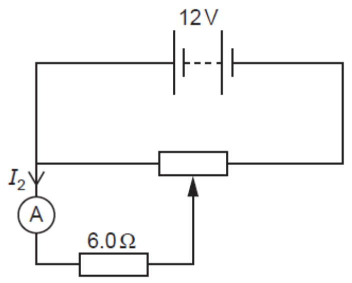


Fig. 4.2

(i) State what is the value of the resistance set for *R* when the maximum possible current I_2 flows through the ammeter.

R = ……………… Ω [1]

(ii) Calculate the maximum possible current I_2 flows through the ammeter.

maximum possible current = …………………. A [2]

(iii) Determine the current I_2 that flows through the ammeter when the variable resistor *R* is set at 6.0 Ω.

....

....

....

....

....

....

.... [2]

5 Fig. 5.1 shows the cross-section of two long straight wires X and Y perpendicular to the page. There is an electric current in both wires out of the page. The current in wire X is twice the current in wire Y.

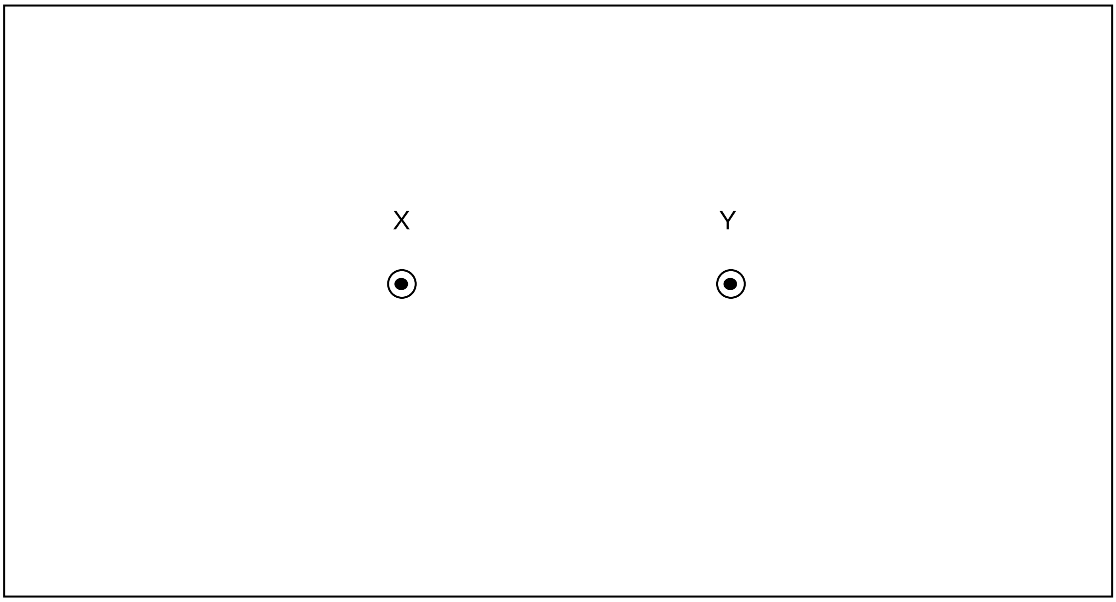


Fig. 5.1

(a) Sketch the resultant magnetic field pattern around the wires within the shaded area. Include direction arrows on the field lines. [4]

(b) Each wire exerts a force on the other wire. Put arrows on the wires to show the direction of these forces. [1]

(c) Explain what Newton's third law implies about the magnitude of these forces.

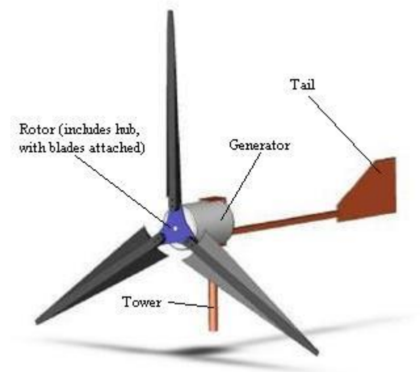
....

....

....

.... [1]

6 Wind turbines (windmills) similar to the one shown in Fig. 6.1 have been used since 1870.



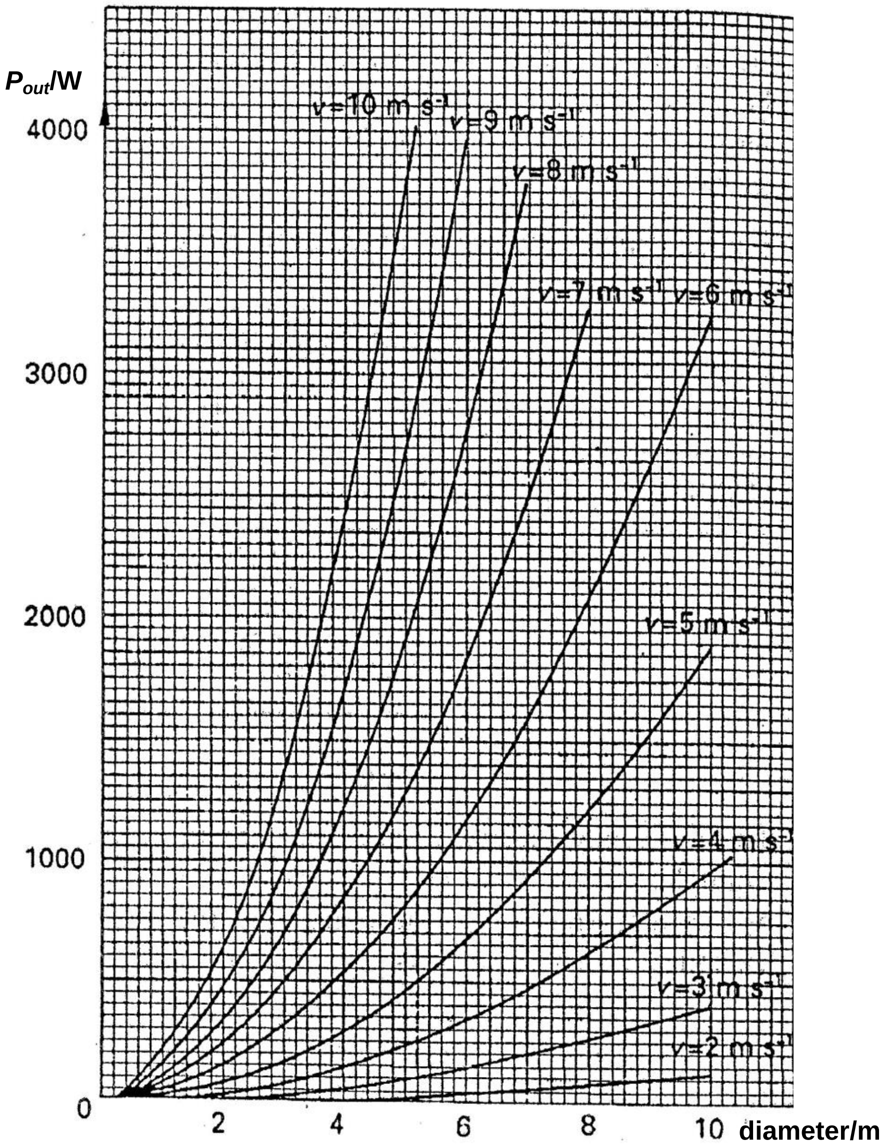
http://wind.find8dev.com/Resources/WindEnergyBasics.asp

Fig. 6.1

The blade surfaces are designed to make the blades spin when wind is incident on the blades. The tail behind the windmill keeps the windmill facing the wind. The diameters of the windmills vary from 2 m to a practical maximum of about 12 m. They will start freely with wind speeds as low as 2 m s^{-1} and, at these low speeds, can produce large torques.

Fig. 6.2 shows how P, the output power of these windmills, varies with the overall diameter of the windmill for different wind speeds, v.

Fig 6.2



(a) Fig. 6.3 shows the values of P_{out}, v, lg P_{out} and lg v for a windmill of diameter 6.0 m.

P_{out}/W	v/m s^{-1}	lg (P_{out}/W)	lg (v/m s^{-1})
50	2.0	1.699	0.301
150	3.0	2.176	0.477
	4.0		0.602
675		2.829	
1175	6.0	3.070	0.778

Fig. 6.3

(i) Complete Fig. 6.3. [1]

For Examiner's Use

(ii) It is suggested that lg P_{out} is directly proportional to lg v. Justify whether this claim is true.

.... [1]

(b) Electrical power is generated from the kinetic energy of the wind when it causes the windmill blades to spin.

Show that for a given diameter, the input power is related to the wind speed by the equation

$$P_{in} = 1/2\rho Av^3$$

where ρ is the density of the air and A is the area covered by the windmill blades when they are spinning.

[2]

(c) **(i)** Given that the density of air is 1.3 kg m^{-3}, determine the power input provided by a wind speed of 6.0 m s^{-1} on a windmill of diameter 7.0 m.

Power =.......................... W [1]

(ii) Hence, determine the efficiency of the windmill when diameter is 7.0 m.

Efficiency = …………………….. [2]

(d) State one other factor that is likely to influence the output power other than wind speed and diameter of the windmill.

.... [1]

(e) In practice, it is difficult to scale up the size of a windmill to very large diameters to generate even more power. Suggest a reason for this limitation.

.... [1]

For Examiner's Use

Section B

Answer any **two** questions for this section.

7 (a) Define *acceleration*.

....

....

.... [1]

(b) Fig 7.1 shows how the vertical speed of a parachutist changes with time during the first 20 s of his jump. To avoid air turbulence caused by the aircraft, he waits a short time after jumping before pulling the cord to release his parachute.

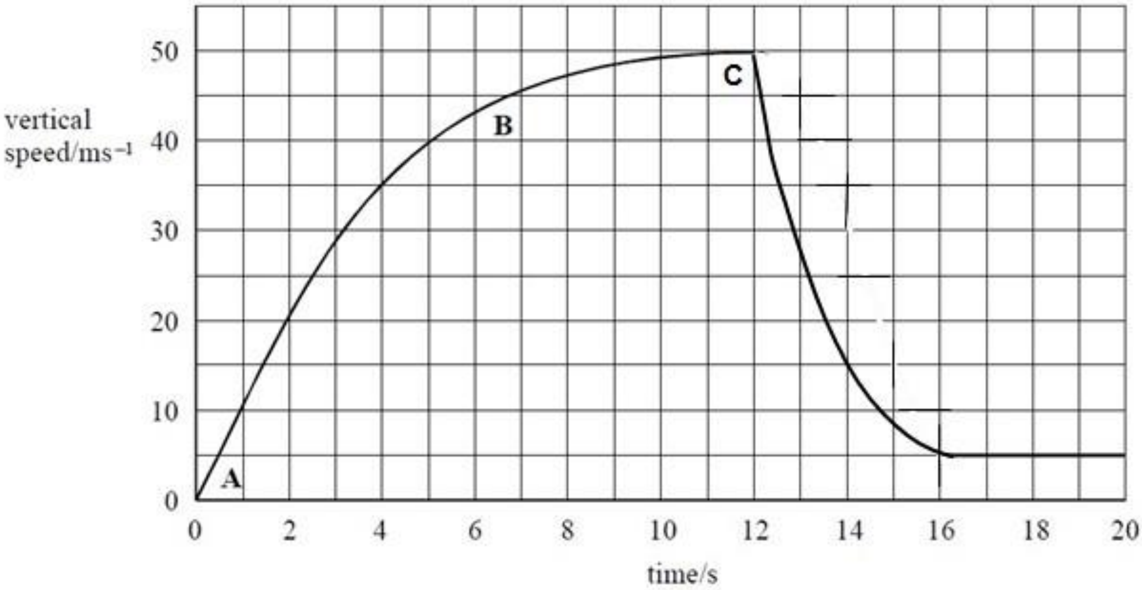


Fig 7.1

(i) Using Fig 7.1, determine the total vertical distance fallen by the parachutist in the first 11 s of the jump. Show your method clearly

Vertical distance fallen = ... m [3]

For Examiner's Use

(ii) **Regions A** (0 to 2 s), **B** (2 to 11 s) and **C** (11 to 12 s) of the graph show the speed before the parachute was opened. With reference to the forces acting on the parachutist, explain why the graph has this shape in the region marked,

1. A

....

....

.... [2]

2. B

....

....

....

.... [2]

3. C

....

....

....

.... [2]

(iii) Determine the acceleration of the parachutist at 6.0 s.

accerleration = ... m s^{-2} [2]

(iv) Complete Fig 7.2 and hence deduce whether the air resistance experienced by the parachutist from 3.0 s to 9.0 s is directly proportional to the square of the velocity of the parachutist.

Take the acceleration of free-fall is given as 10.0 m s^{-2}.

***t*/s**	***v*/ m s^{-1}**	***a*/ m s^{-2}**	**(*g* – *a*) / m s^{-2}**	
3.0	28.5	6.90	3.10	
6.0	43.0			
9.0	48.0	1.20	8.80	

Fig 7.2

....

....

....

.... [4]

For Examiner's Use

(c) **(i)** Show that the maximum deceleration of the parachutist when the parachute opened at time 12 s is about 30 m s^{-2}.

[1]

(ii) Hence draw a graph on Fig 7.3 showing the variation with time of the acceleration of the parachutist during the first 18 s of the jump.
(No further calculations required.)

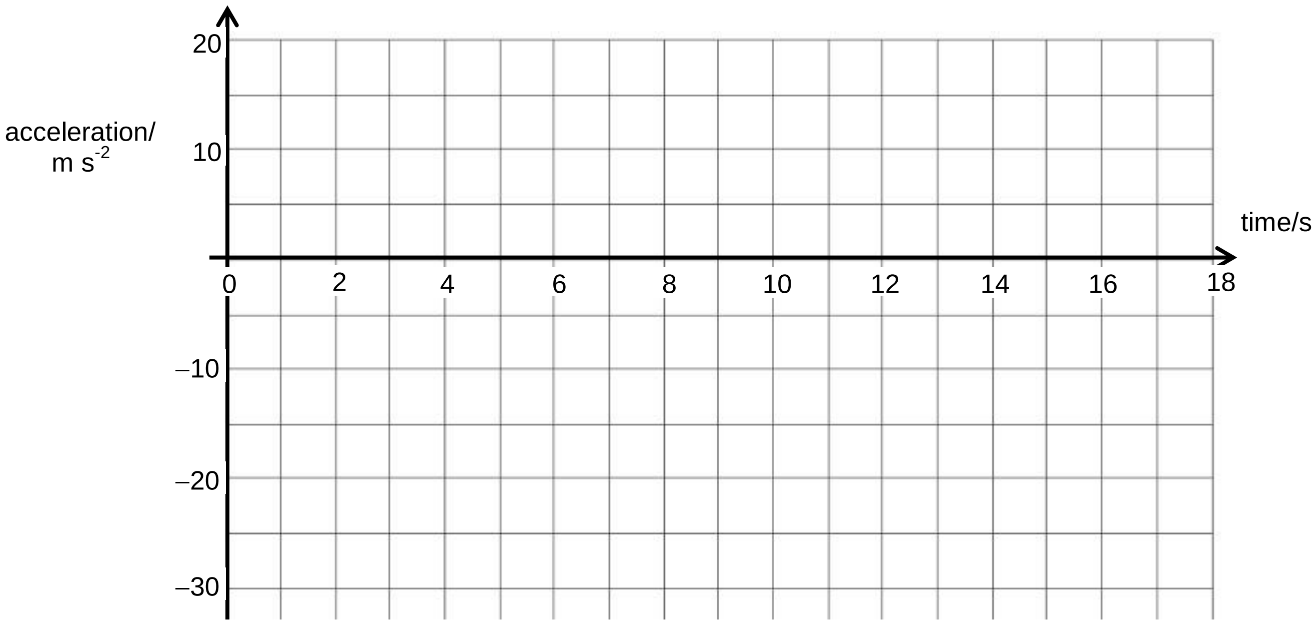


Fig 7.3

[3]

For Examiner's Use

8 **(a)** Explain what is meant by the term *interference*.

....

....

....

.... [2]

(b) A Kundt's tube is an experimental acoustical instrument that serves to measure the speed of sound in different medium.

It comprises of a long horizontal tube, containing a fine powder, which is closed at one end. A loudspeaker connected to a signal generator is positioned at the other end. The device is shown in Fig. 8.1 and the signal generator is set to a frequency of 400 Hz.

From the *interference* of waves resulting in stationary waves being formed, an interesting pattern can be observed as seen in Fig. 8.1.

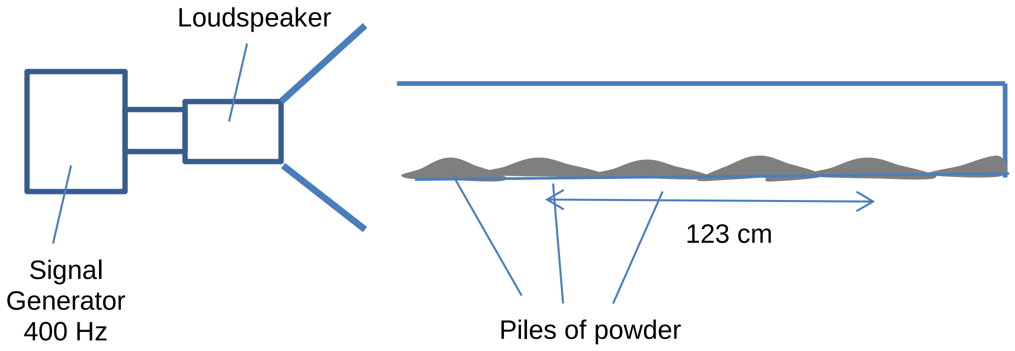


Fig. 8.1

(i) Label the positions of nodes (**N**) and antinodes (**A**) on Fig. 8.1

[1]

(ii) Explain the formation of the piles of fine powder at the positions shown on Fig. 8.1.

....

....

....

.... [3]

(iii) Hence or otherwise, determine the speed of the sound waves in that medium.

Speed of Sound = ... m s^{-1} [2]

For Examiner's Use

(iv) The speed of sound is dependent on temperature *T*(in Celsius)

$$speed\ of\ sound\ in\ air\ = 331.4 + 0.6\,T\ ms^{-1}$$

State and explain what will happen to the distance between consecutive piles as compared to Fig. 8.1 if the instrument is brought to an altitude 1000 m above the sea level where the temperature is lower.

[3]

(v) A similar experiment is replicated with a sample of helium gas instead of normal air composed mainly of nitrogen.
By considering the helium gas to be a less dense medium where the sound waves travel faster within it, state and explain what will happen to the distance between consecutive piles as compared to Fig. 8.1.

[4]

(c) By increasing the frequency of the source slowly, it is observed that the tube actually goes through *resonance* at certain frequencies, such as 400 Hz,

(i) Determine the length of the instrument using speed of sound as

Length of instrument = ... cm [2]

(ii) However, it is noticed that the length that is measured is slightly different from the calculated value.

This phenomenon is known as .... [1]

(d) From (c)(i) or otherwise, determine the next higher frequency that will result in the power being gathered at definite spots again.

Frequency = Hz [2]

For Examiner's Use

9 **Fig. 9.1** shows how emission and absorption spectra can be obtained.

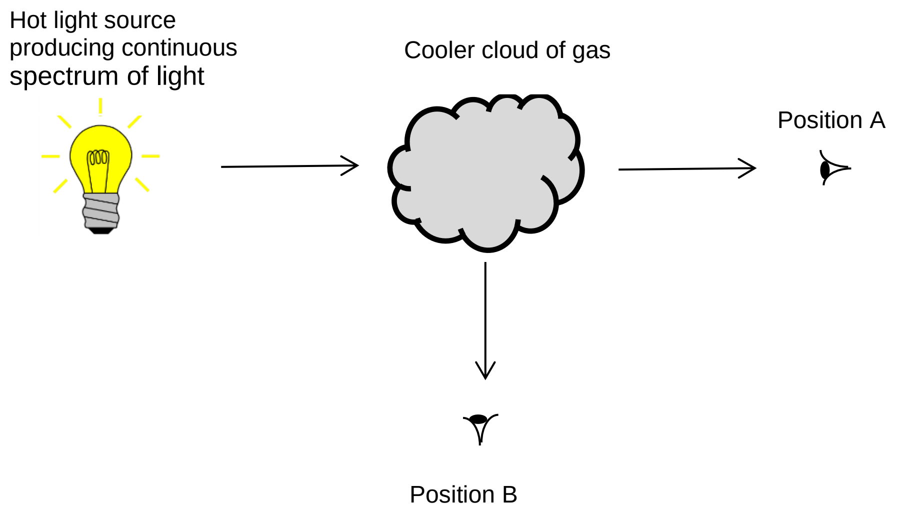


Fig. 9.1

(a) **(i)** State the type of spectrum the eyes at position A and B are expected to see:

Position A : _______________ spectrum

Position B : _______________ spectrum

[1]

(ii) Explain how the emission spectrum is an evidence for discrete energy levels in an atom.

....

....

....

....

.... [2]

(iii) Suggest how absorption spectrum can be used to identify elements present in the sun.

....

....

....

....

.... [2]

For Examiner's Use

(b) (i) Explain what is meant by wave-particle duality.

....

....

....

....

.... [2]

(ii) State and explain one observation from the photoelectric effect experiment that provides the evidence for this phenomenon.

....

....

....

....

.... [2]

(c) **Fig. 9.2** shows the maximum kinetic energy of the emitted photoelectrons as the frequency of the incident radiation on a sodium plate is varied.

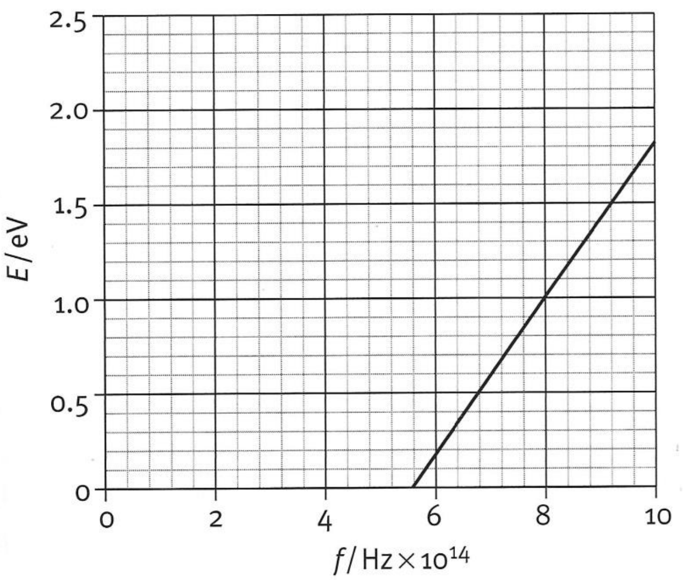


Fig. 9.2

(i) Explain why there is no photoelectrons emitted when the frequency of the incident light is less than 5.6×10^{14} Hz.

....

....

....

....

.... [2]

For Examiner's Use

(ii) Calculate the work function for sodium.

Work function = ………………… J

[2]

(iii) Use Fig. 9.2 to calculate the value of the Planck constant in J s.

Planck constant = …………………… J s [3]

(iv) State and explain how the graph will change if sodium is replaced with a metal of lower work function.

[4]