H

NANYANG JUNIOR COLLEGE
JC 2 PRELIMINARY EXAMINATION
Higher 1

CANDIDATE NAME			
CLASS		TUTOR'S NAME	

PHYSICS

8866/02

Paper 2 Structured Questions

17 September 2015

2 hours

Candidates answer on the Question Paper.

No Additional Materials are required

READ THESE INSTRUCTIONS FIRST

Write your name and class on all the work you hand in.
Write in dark blue or black pen on both sides of the paper.
You may use a soft pencil for any diagrams, graphs or rough working.
Do not use staples, paper clips, highlighters, glue or correction fluid.

The use of an approved scientific calculator is expected , where appropriate

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 Examiner's Use	
Section A	
1	
2	
3	
4	
5	
Section B	
6	
7	
8	
Total	

This document consists of **23** printed pages.

[Turn over

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	=	ρgh
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** questions in this section.

1 A speed-time graph for an MRT train travelling between two stations is shown in Fig. 1.1.

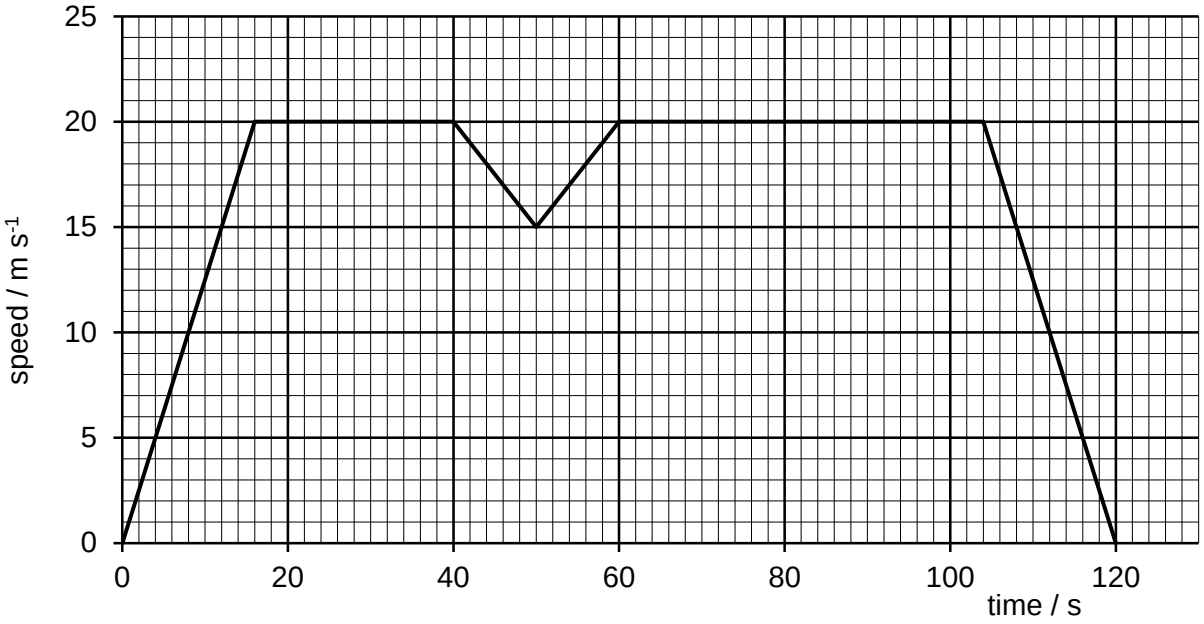

Fig 1.1

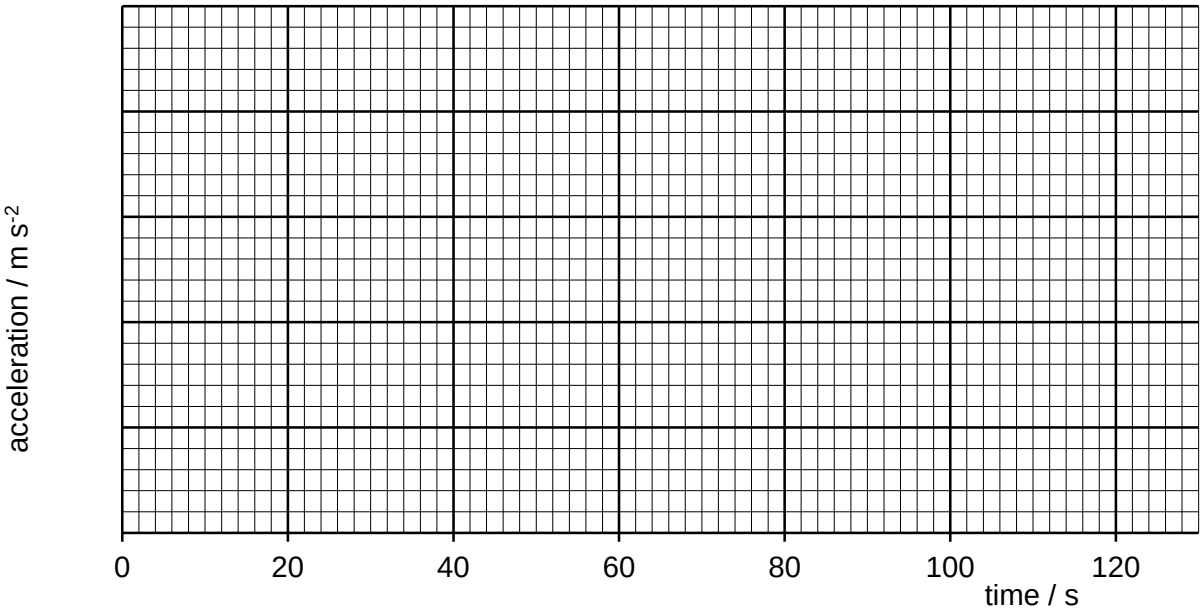

Fig 1.2

(a) On Fig. 1.2, draw the corresponding acceleration-time graph. Put numerical values on the acceleration axis. [2]

(b) Calculate the distance travelled between the two stations.

distance = ... m [2]

(c) On Fig.1.3, sketch a labelled distance-time graph of the train between the two stations.

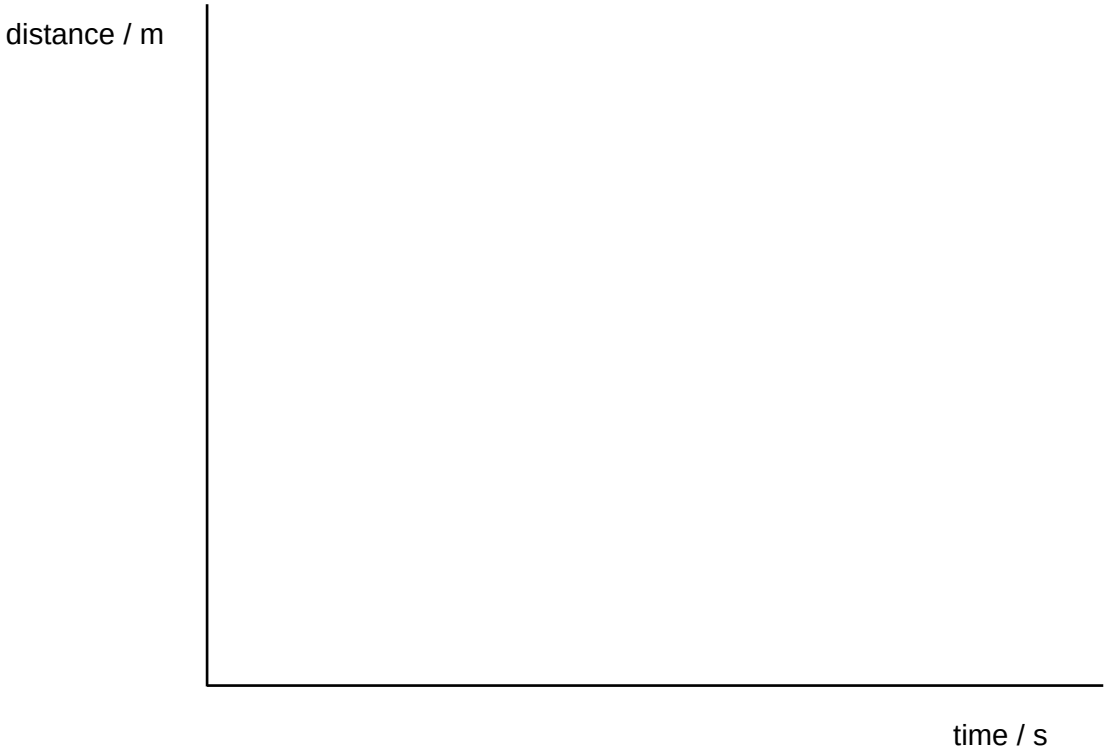

Fig 1.3

[2]

2 Sail systems are being developed to reduce the running costs of cargo ships. The sail and ship's engines work together to power the ship. One of these sails is shown in Fig. 2.1, pulling the ship at an angle of 40^{o} to the horizontal.

Fig. 2.1

With the sail and the engines operating, the ship is travelling at a steady speed of 7.0 m s^{-1}.

(a) The average tension in the cable is 170 kN. Show that, when the ship travels 1.0 km, the work done by the sail on the ship is 1.3×10^8 J. [2]

(b) **(i)** Calculate the power developed by the sail.

power = ... W [2]

(ii) Calculate the percentage of the ship's power requirement that is provided by the wind when the ship is travelling at this speed.

The power output of the engines is 2.1 MW.

percentage = ... % [2]

(c) The angle of the cable to the horizontal is one of the factors that affects the horizontal force exerted by the sail on the ship. State one other factor that would affect this force.

.....

..... [1]

For Examiner's Use

3 Fig. 3.1 below shows the I-V graphs for conductors X and Y.

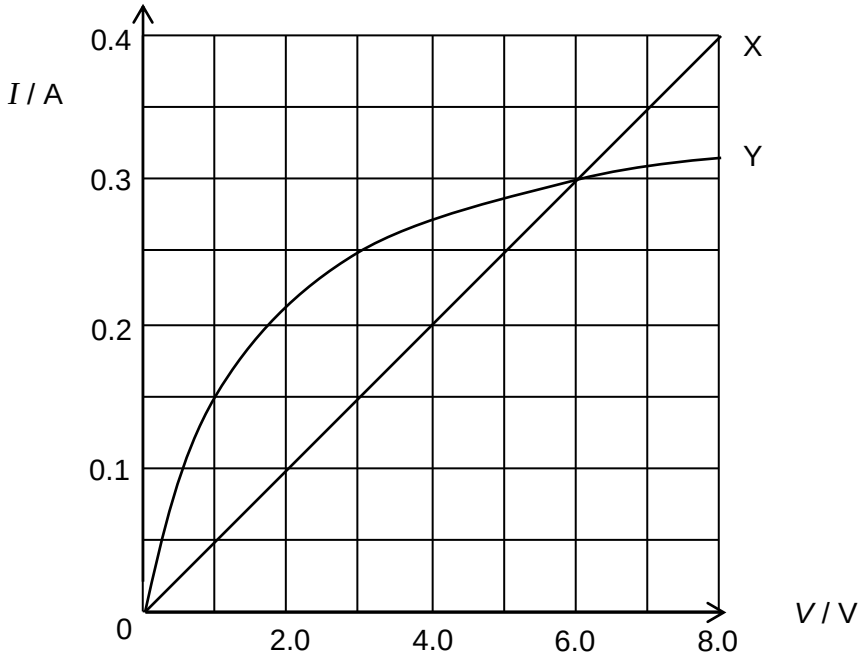

Fig. 3.1

(a) Deduce the type of conductors X and Y are.

X : .....

Y : ..... [2]

(b) Conductors X and Y are arranged in parallel and connected to a cell in a closed circuit. Draw a circuit diagram in the space below to show the arrangement.

[1]

(c) The current in X is 0.15 A. Using the graphs given, determine the current in the cell.

current in cell = ... A [2]

(d) The e.m.f. of the cell is 3.3 V. Calculate the internal resistance of the cell.

internal resistance = ... Ω [2]

4 **(a)** Fig. 4.1 shows two wires, X and Y, carrying currents of equal magnitude but in opposite direction.

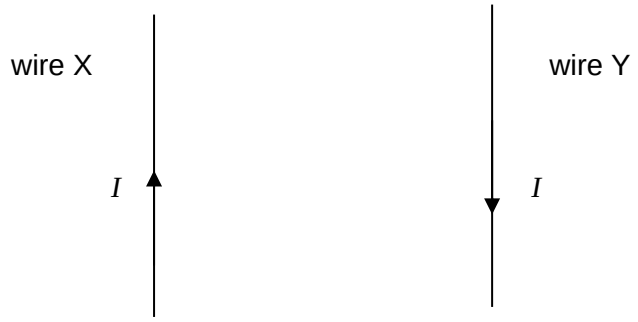

Fig. 4.1

Fig. 4.2 shows the top view of the wires.

Fig. 4.2

(i) On Fig. 4.2, sketch the magnetic field pattern around the two wires. [2]

(ii) On Fig. 4.1, draw the direction of the force acting on wire Y. Label the force *F*.[1]

(b) Fig. 4.3 shows a wire of weight 0.100 N and length 1.00 m carrying a current of 5.0 A, suspended by two identical springs of spring constant 2.50 N m^{-1}.

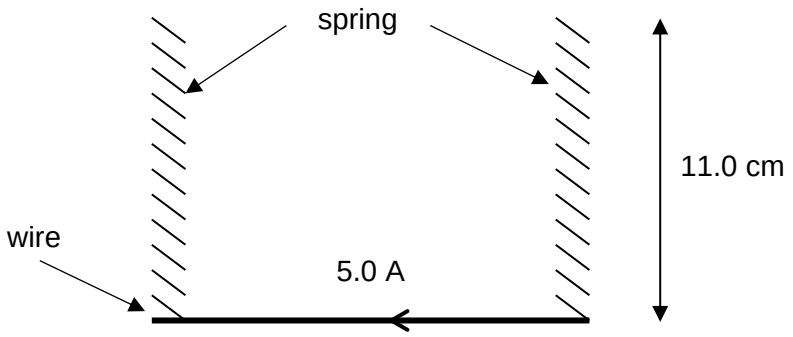

Fig. 4.3

The whole wire is in a region of constant magnetic field and the field is perpendicular to the wire.

The natural length of the spring is 10.0 cm. The system is in equilibrium and the wire is horizontal.

(i) Using the weight of the wire and the spring constant, explain quantitatively why the direction of the magnetic field is out of the page.

.....

.....

..... [2]

(ii) Calculate the magnetic flux density of the field.

magnetic flux density = ... T [3]

5 Bats emit high frequency sound waves and receive reflected echoes. They use the echoes to locate their position. This process is called echolocation.

Fig. 5.1 illustrates this process.

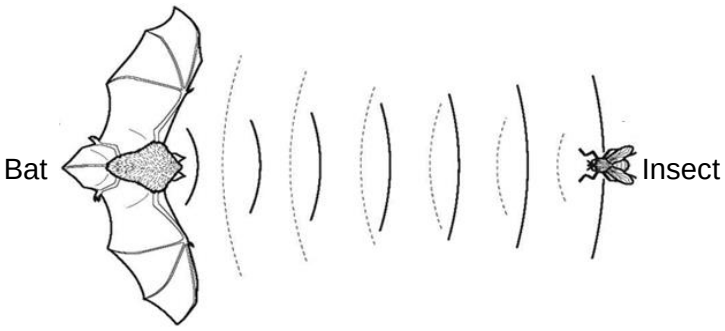

Fig. 5.1

(a) Sound waves emitted by the bat travel at 340 m s^{-1}. Their typical frequency range is 20 kHz to 80 kHz.

Calculate the range of wavelengths for this frequency range.

range of wavelength = ... to ..... m [2]

(b) Bats emit two waveforms, wave B and wave P, which superpose to form wave E.
- Wave B (shown in Fig. 5.2) gives information about the surrounding background.
- Wave P (not shown in Fig. 5.2) enables the bat to detect insect prey.
- Wave E (shown in Fig. 5.2) is the superposition of wave B and wave P.

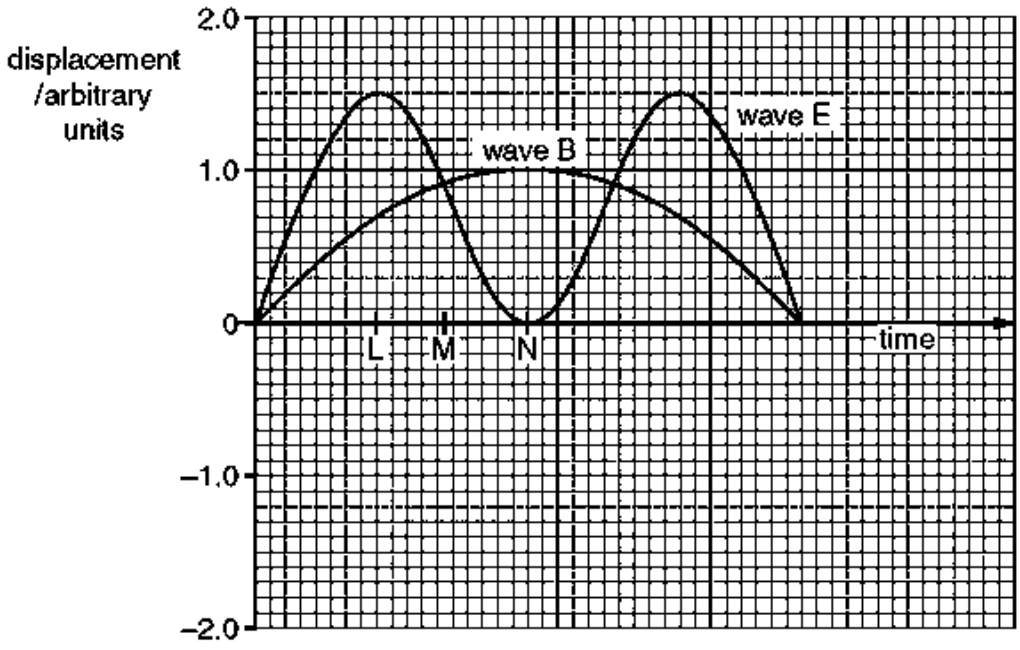

Fig. 5.2

(i) Use the principle of superposition to determine the displacement of wave P at times corresponding to points L, M and N on the time axis.

Write the displacement values in the spaces provided.

displacement of wave P at L = ... units

displacement of wave P at M = ... units

displacement of wave P at N = ... units [2]

(ii) Hence draw the waveform for wave P on Fig. 5.2. [2]

(c) An effect known as the Doppler effect uses changes in frequency to determine speeds. The change in frequency, Δf, shown by wave P when it is reflected by an insect travelling with speed v, is given approximately by the formula

$$\frac{\Delta f}{f} = \frac{2v}{c}$$

where c represents the speed, 340 m s^{-1}, of sound waves emitted by the bat.

(i) Wave P has a frequency of 50.80 kHz. Its apparent frequency after reflection is 51.25 kHz

Calculate the speed of the insect.

speed of insect = ... m s^{-1} [2]

(ii) The bat best discriminates small insect prey when the wavelength of the reflected wave P is similar in size to the insect.

State the wave property that is being demonstrated in this situation

..... [1]

(d) The bat's high frequency waves are strongly attenuated in air. Fig. 5.3 is a graph of intensity I against range in air x for the high frequency waves.

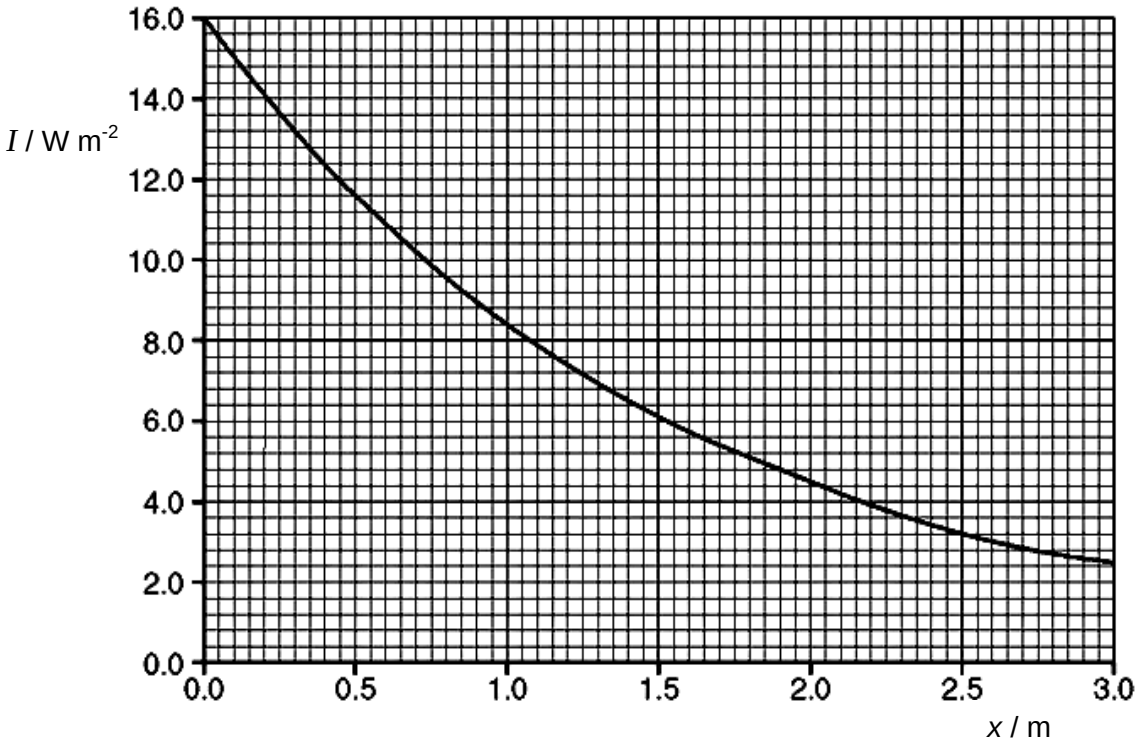

Fig. 5.3

The shape of the curve in Fig. 5.3 suggests that the decrease of the intensity I with range in air x could be exponential. In order to test this suggestion, a graph of ln (I) against x is plotted. This is shown in Fig. 5.4.

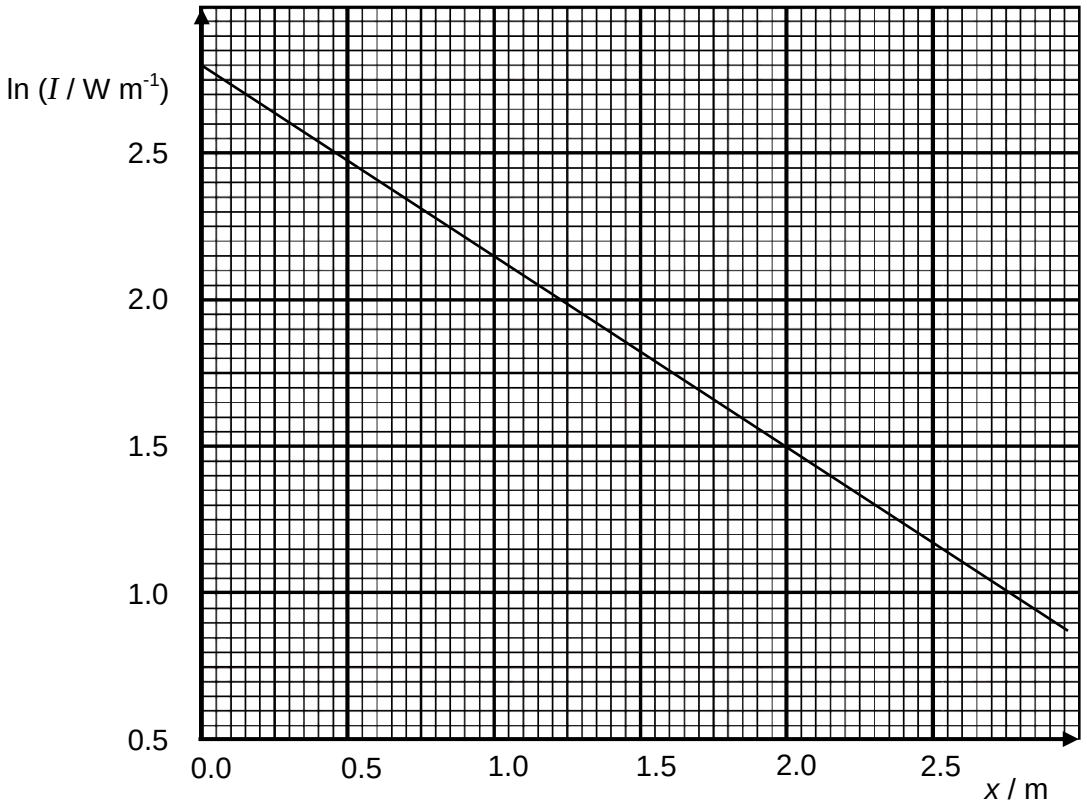

Fig. 5.4

Show that Fig. 5.4 indicates a relationship of the form

$$I = I_0 e^{-\alpha x}$$

where α is a constant.

.....

.....

.....

..... [3]

Section B

Answer **two** of the questions in this section.

6 **(a)** State Newton's second law and show how it leads to the relationship:

$$\text{force} = \text{mass} \times \text{acceleration}$$

for a body of constant mass. [3]

(b) Fig. 6.1 below shows the top view of a train consisting of an engine pulling a cargo carriage and 2 passenger carriages. The mass of the engine, cargo carriage and each of the passenger carriages are 3500 kg, 7500 kg and 4500 kg respectively. The frictional force of the track acting on the engine, cargo carriage and each of the passenger carriages are 2.0 kN, 4.0 kN and 3.0 kN respectively.

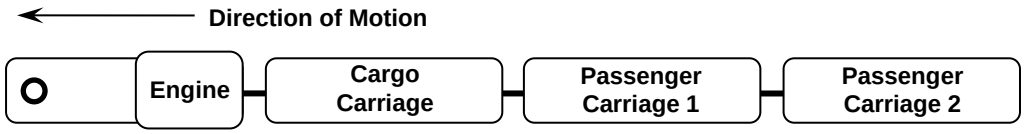

Fig. 6.1

(i) The train accelerates from rest to its operating speed of 30 m s^{-1} in 40 s.

1. Determine the driving force provided by the engine, assuming that acceleration during this period is constant and air resistance on the train is negligible.

driving force = ... N [3]

2. Calculate the distance travelled by the train during this period. Hence or otherwise, determine the average power of the engine during this period.

distance travelled = ... m [1]

average power = ... W [2]

3. By considering the forces acting on an appropriate body, determine the force in the connection between the cargo carriage and passenger carriage 1.

force = ... N [3]

(ii) The train operator is studying the feasibility of making an additional stop at a certain town. Based on their current schedule, the maximum allowable delay is 5 minutes. The train has a deceleration of 2 m s^{-2}.

1. Calculate the time taken for the train to decelerate from its operating speed to rest, as well as the distance travelled during its deceleration.

time taken = ... s [1]

distance travelled = ... m [1]

2. Determine the time delay due to the train accelerating and decelerating, and hence calculate the maximum time which the train may stop at the station.

time delay = ... s [2]

maximum time = ... s [1]

(iii) At the train depot, the passenger carriages are sometimes hoisted off the tracks using a light, frictionless pulley system as shown in Fig. 6.2.

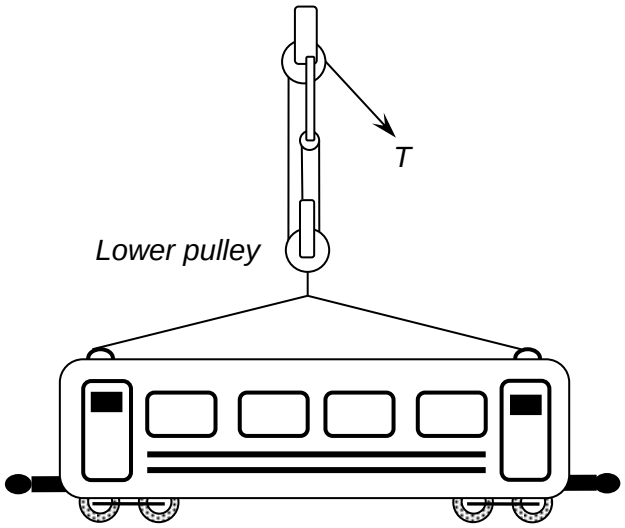

Fig. 6.2

By considering the forces acting on the lower pulley, determine the force *T* required to suspend the carriage in mid-air.

T = ... N [3]

7 **(a)** Explain what is meant by the superposition of waves.

.....

.....

..... [2]

(b) Two loudspeakers connected to the same voltage signal generator, are placed 5.0 m apart at P and Q. An observer A is 12.0 m from P and another observer B is at the perpendicular bisector of PQ, as shown in Fig. 7.1.

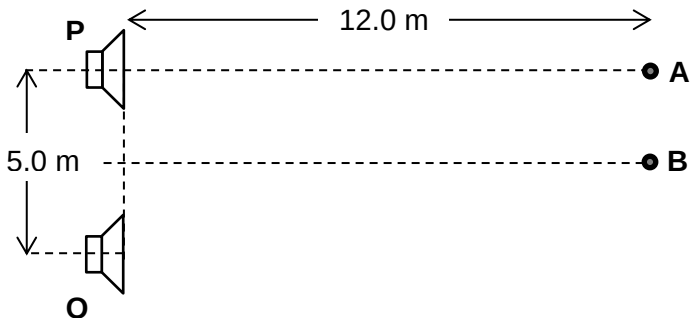

Fig. 7.1

When the loudspeakers are first switched on, producing 340 Hz tones, both observers can barely detect any sound.

(i) State the phase difference between the sound waves produced by the two loudspeakers.

phase difference = ... [1]

(ii) Describe and explain what the two observers will hear when the frequency of the signal generator is gradually increased from 340 Hz.

Observer A:

.....

.....

.....

.....

.....

.....

Observer B:

.....

.....

.....

..... [5]

(iii) Calculate the frequency of the signal generator at which observer A detects sound of maximum intensity for the first time as the sound frequency is gradually increased from 340 Hz. (speed of sound in air = 340 m s^{-1})

frequency = ... Hz [3]

(c) One of the loudspeakers is now placed near one of the ends of a narrow open telescopic tube, as shown in Fig. 7.2. The signal generator is set at 520 Hz.

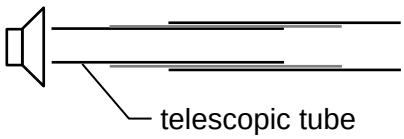

Fig. 7.2

(i) Describe and explain what is observed as the tube is gradually extended.

.....

.....

.....

.....

..... [3]

(ii) Calculate the minimum length of the tube at which a loud sound is observed.

minimum length = ... m [2]

(iii) The loud sound in **(ii)** has a fundamental frequency of 540 Hz, as well as other secondary frequencies known as harmonics. Calculate one of these frequencies. Explain your working clearly.

frequency = ... Hz [2]

(iv) Fig. 7.3 shows a double bass and a violin.

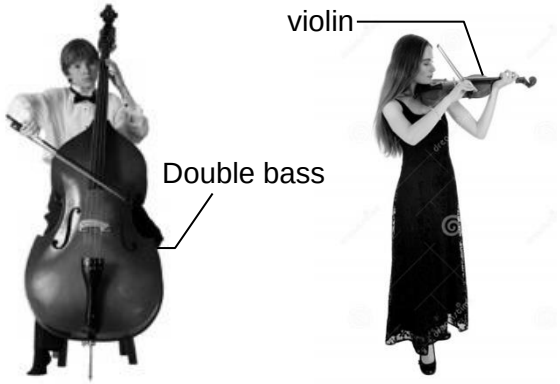

Fig. 7.3

The two musical instruments are very different in size, even though they are similar in shape. Suggest why this is so.

.....

.....

..... [2]

8 **(a)** For a particular metal surface, it is observed that there is a minimum frequency of light below which photoelectric emission does not occur. This observation provides evidence for a particulate nature of electromagnetic radiation.

State three further observations from photoelectric emission that provide evidence for a particulate nature of electromagnetic radiation.

1. .....

.....

.....

2. .....

.....

.....

3. .....

.....

..... [3]

(b) Some data for the variation with frequency f of the maximum kinetic energy E_{MAX} of electrons emitted from a metal surface are shown in Fig. 8.1.

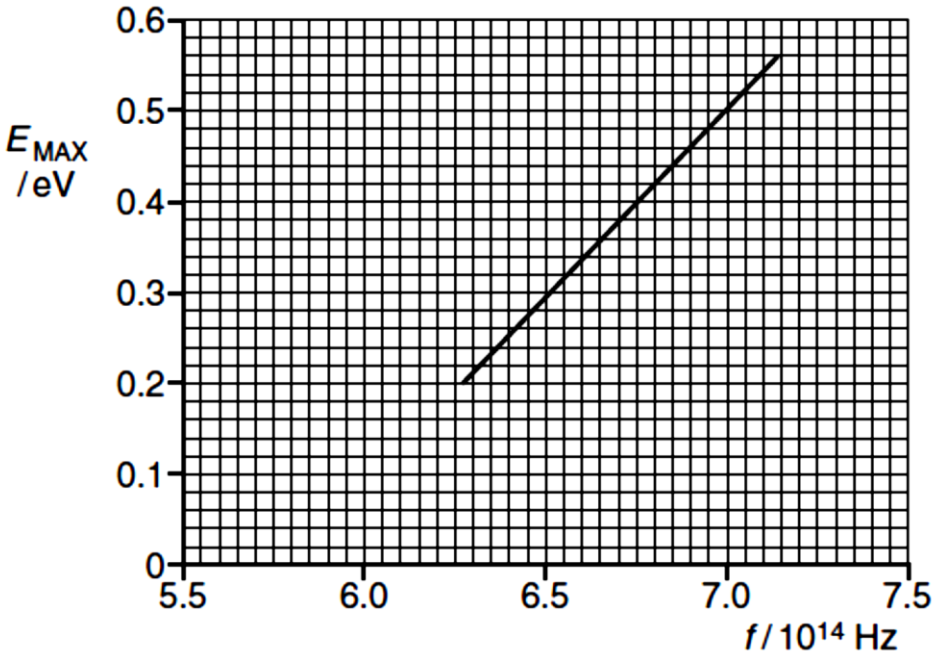

Fig. 8.1

(i) Explain why emitted electrons may have kinetic energy less than the maximum value at any particular frequency.

.....

.....

..... [2]

(ii) Use Fig. 8.1 to determine

1. the threshold frequency,

threshold frequency = ... Hz [1]

2. the work function energy, in eV, of the metal surface.

work function = ... eV [2]

(c) White light is incident on a cloud of cool hydrogen gas, as illustrated in Fig. 8.2.

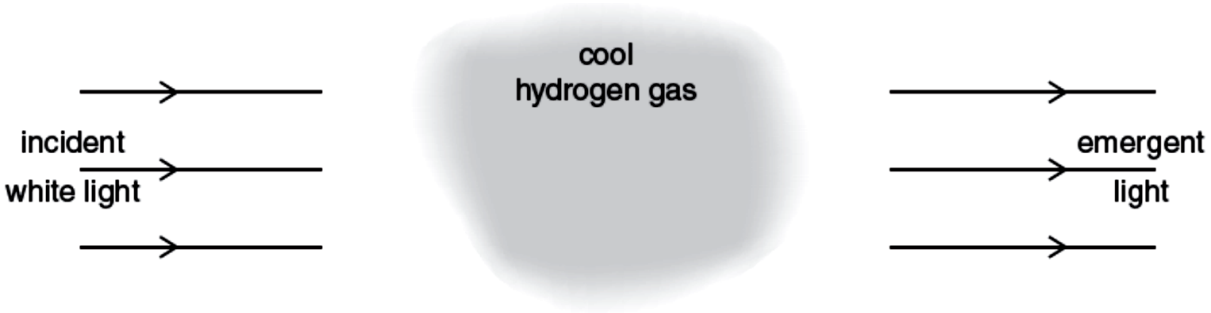

Fig. 8.2

The spectrum of the light emerging from the gas cloud is found to contain a number of dark lines.

(i) Explain why these dark lines occur.

.....

.....

.....

.....

.....

.....

..... [4]

(ii) Some electron energy levels in a hydrogen atom are illustrated in Fig. 8.3.

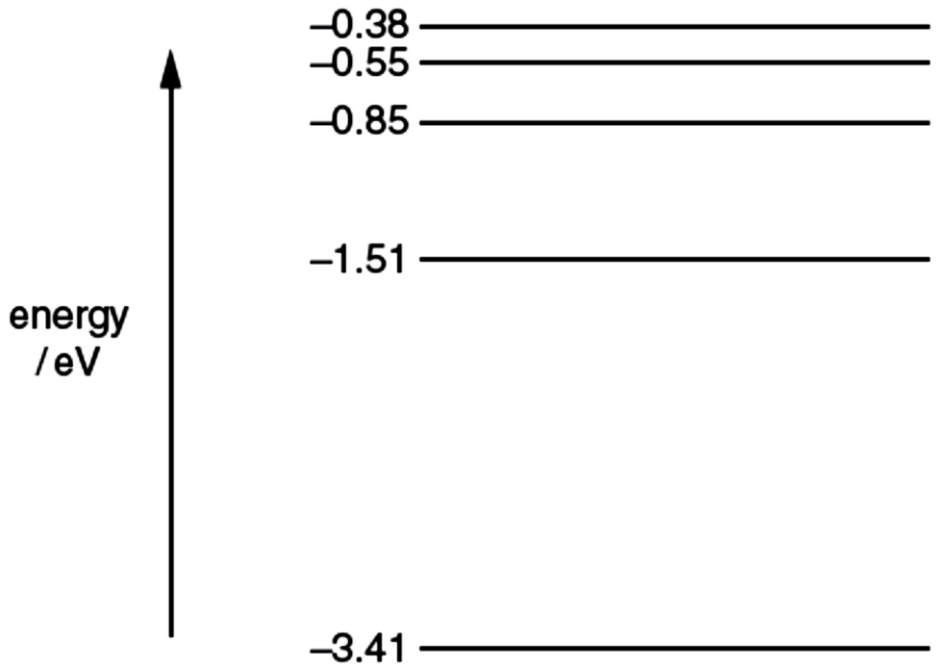

Fig. 8.3

One dark line is observed at a wavelength of 435 nm.

On Fig. 8.3, draw an arrow to indicate the energy change that gives rise to this dark line. [1]

(d) A beam of light is incident normally on a metal surface, as illustrated in Fig. 8.4.

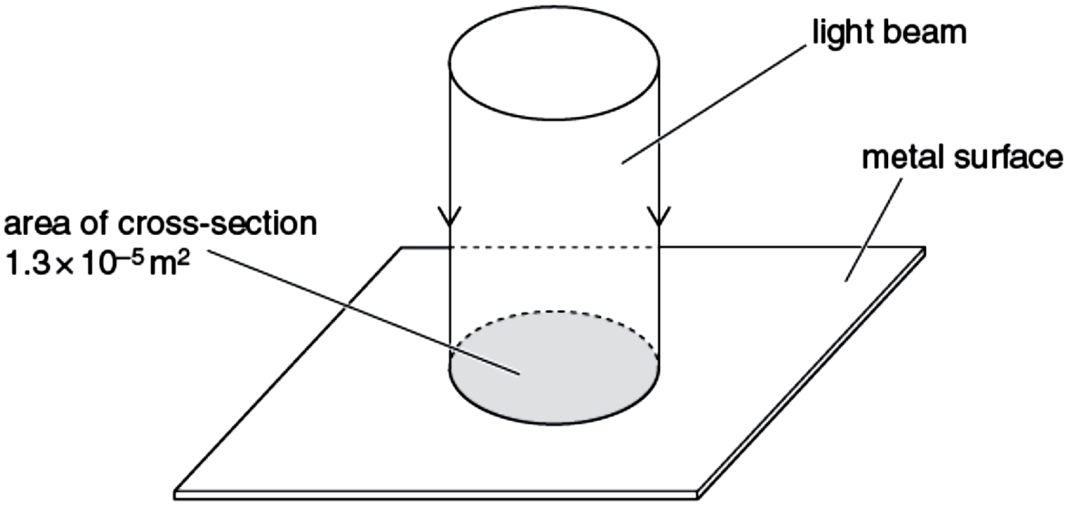

Fig. 8.4

The beam of light has cross-sectional area 1.3×10^{-5} m^2 and power 2.7×10^{-3} W. The light has wavelength 570 nm.

The light energy is absorbed by the metal and no light is reflected.

(i) Show that a photon of this light has energy of 3.5×10^{-19} J. [1]

(ii) Calculate, for a time of 1.0 s,

1. the number of photons incident on the surface,

number of incident photons = ... [2]

2. the change in momentum of each photon.

change in momentum = ... N s [2]

(iii) Use your answer in **(d)(ii)** to calculate the pressure that the light exerts on the metal surface.

pressure = ... Pa [2]