H

NANYANG JUNIOR COLLEGE
JC2 PRELIMINARY EXAMINATION
Higher 1

CANDIDATE NAME	

CLASS		TUTOR'S NAME	

PHYSICS **8866/02**

Paper 2 Structured Questions **19 September 2014**

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.

Section A
Answer **all** questions.

Section A
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	
6	
Section B	
7	
8	
9	
Total	

Data

speed of light in free space,	$c = 3.00 \times 10^{8}$ m s^{-1}
elementary charge,	$e = 1.60 \times 10^{-19}$ C
the Planck constant,	$h = 6.63 \times 10^{-34}$ J s
unified atomic mass constant,	$u = 1.66 \times 10^{-27}$ kg
rest mass of electron,	$m_e = 9.11 \times 10^{-31}$ kg
rest mass of proton,	$m_p = 1.67 \times 10^{-27}$ 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,	$p = \rho gh$
resistors in series,	$R = R_1 + R_2 + \ldots$
resistors in parallel,	$1/R = 1/R_1 + 1/R_2 + \ldots$

Section A

Answer **all** questions in this section.

1 **(a)** A 0.150 kg toy helicopter is moving at a constant altitude of 75.0 m with a speed of 1.50 m s^{-1} when a shooter fires vertically up and hits the target as shown in Fig. 1 Given that the mass of the bullet is 1.00 g and the initial speed of the bullet is 100 m s^{-1}. Assume negligible air resistance and ignore height of shooter, determine

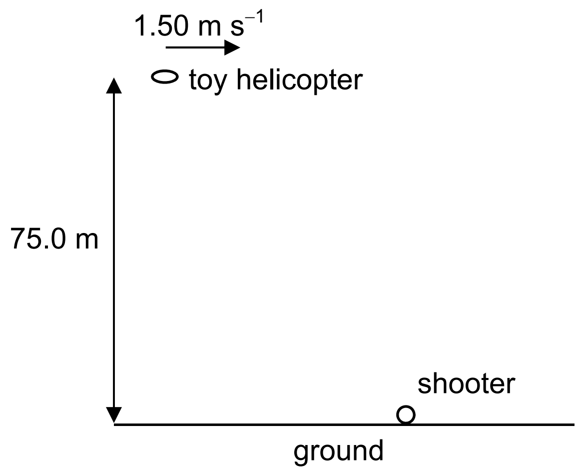


Fig. 1

(i) the distance of the toy helicopter from the shooter when he shoots

distance = ………………………………… m [3]

(ii) the momentum of the toy helicopter and bullet immediately after the hit. Assume that the bullet is embedded in the toy helicopter after the hit.

magnitude of momentum = ………………………………… kg m s^{-1} [2]

(b) State and explain whether principle of conservation of momentum is violated for the toy helicopter in **(a)** considering its motion immediately after the hit and just before it hits the ground.

………………………………………………………………………………………………………...

………………………………………………………………………………………………………...

………………………………………………………………………………………………………...

………………………………………………………………………………………………………...

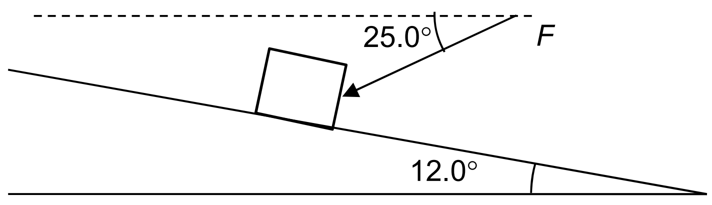
……...……………………………………………………………………………………………. [2]

2 **(a)** State Newton's second law of motion.

………………………………………………………………………………………………………...

……...………………………………………………………………………………………….. [1]

(b) An initially stationary box of weight 15.0 N is being pushed by a force, F, of 32.0 N up a frictionless surface inclined at an angle of 12.0°. Given that the force is directed at an angle of 25.0° below the horizontal,



(i) calculate the acceleration of the box.

acceleration = ………………………………… m s^{-2} [3]

(ii) determine the time needed for the box's speed to increase to 2.50 m s^{-1}.

time taken = …………………………………. s [2]

3 A uniform sheet of steel weighing 800 N is supported by a bolt at its lower-left hand corner and by a cable tied to a point on its left-edge as shown in Fig. 3.1 below. The pull by the cable on the sheet is *T*.

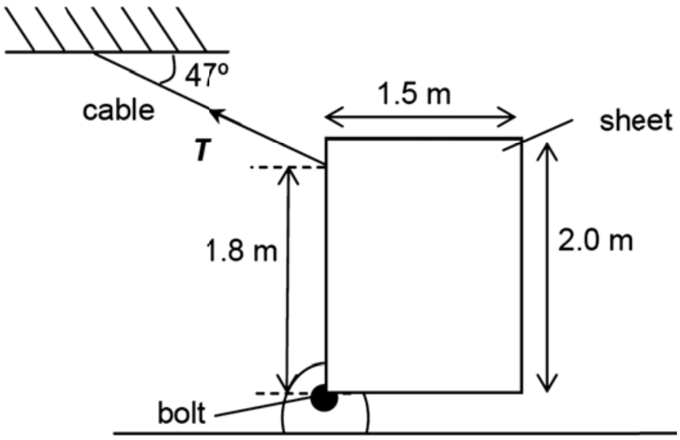


Fig. 3.1

(a) Show that *T* is 489 N.

[2]

(b) Determine the magnitude of force acting on the bolt by the sheet.

magnitude of force = …………………………………. N [3]

4 Fig. 4.1 shows a simple electric motor made up of an armature placed in between 2 permanent magnets. The region of space between the 2 magnets has a magnetic flux density of 40 mT. The armature consists of a single square coil of copper wire with each side of length of 20 cm.

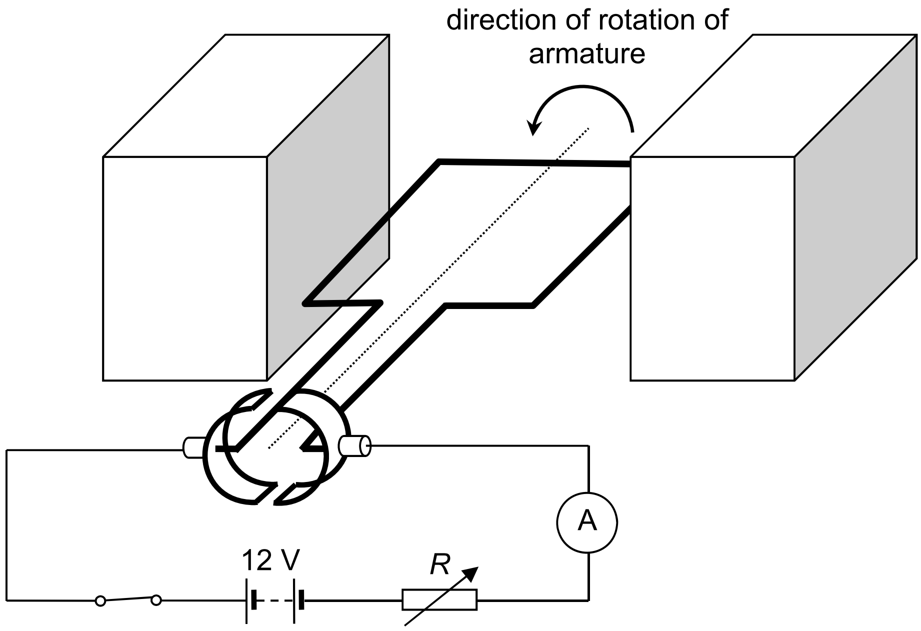


Fig. 4.1

(a) Explain what is meant by a *magnetic flux density of 40 mT*.

…………………………………………………………………………………………………...

……..……………………………………………………………………………………………...

……..………………………………………………………………………………………….. [1]

(b) On Fig 4.1, indicate with an arrow the direction of the magnetic field in the region between the 2 permanent magnets. [1]

(c) The armature carries a current of 0.55 A just before it starts to move from the instant as shown in Fig 4.1. Determine the magnitude of the torque acting on the armature due to the magnetic force at this instant.

torque = ………………………………… N m [3]

5 **(a)** In classical wave theory, light is an electromagnetic wave and the intensity of the wave is proportional to the square of the amplitude of the wave.

But according to Einstein's photon theory, light comes in quanta of electromagnetic energy and each quantum is proportional to the frequency.

In a photoelectric experiment, the intensity or the frequency of the incident light changes accordingly as shown in table below. Fill in the blanks in the table correctly with the following descriptions:

1. Remains the same **2.** increases or **3.** decreases.

	Energy of each photon	Total energy of the light	Number of photons
If the frequency of the light is constant, as the intensity of the light increases….			
If the intensity of the light is constant, as the frequency of the light increases….			

[2]

(b) Electromagnetic radiation is incident normally on the surface of a metal. Electrons are emitted from the surface and these electrons are attracted to a positively charged electrode, as shown in Fig. 5.1.

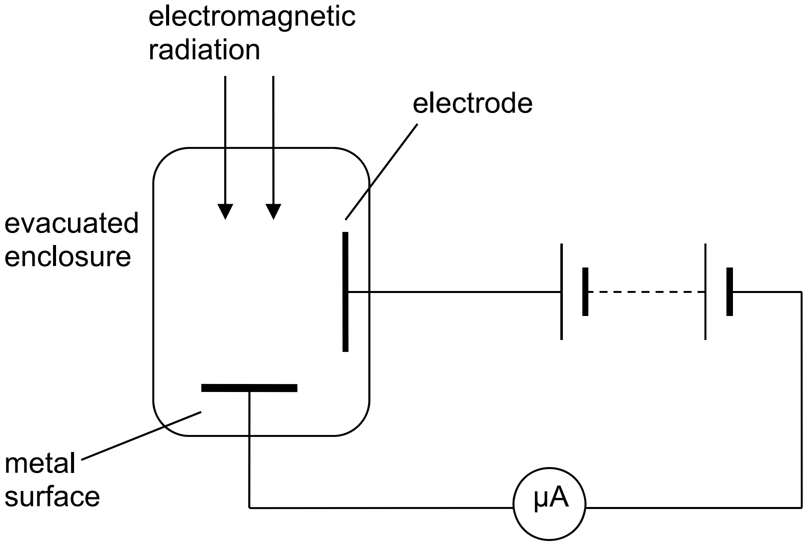


Fig. 5.1

The incident radiation has a wavelength of 240 nm. When the wavelength of the radiation is gradually increased to 310 nm, the reading in the microammeter just drops to zero.

Calculate the maximum kinetic energy of the electrons emitted from the metal surface when the wavelength of the radiation remains at 240 nm.

maximum kinetic energy = ………………………………… J [2]

(c) In the above experiment it was found that the ratio

$$\frac{\text{number of electrons emitted per second}}{\text{number of photons incident per second}}$$

is in the order of 10^{-6}.

Suggest why is the number ratio so small.

…………………………………………………………………………………………………..

……..…………………………………………………………………………………….. [1]

(d) **(i)** Calculate the momentum of the photon with a wavelength of 240 nm.

momentum = ………………………………… N s [1]

(ii) Hence explain why there is a radiation pressure on the metal surface.

………………………………………………………………………………………………

……...………………………………………………………………………………..... [1]

6 Astronauts plan a space expedition to Planet Newtonia to determine its acceleration of free fall.

(a) As part of the preliminary investigations conducted on Earth, a tennis ball is released from the top of a 12 storey building. Estimate the momentum of the tennis ball just before it hits the ground.

momentum = ………………………………… kg m s^{-1} [2]

(b) Upon reaching Planet Newtonia, a scientist takes measurements to determine a value for the acceleration of free fall on Planet Newtonia. A stroboscopic photograph (shown to scale) shows the motion of a free falling tennis ball released from rest. The strobe rate is 10 flashes per second.

Fig. 6.1

(i) Draw a graph on Fig. 6.2 showing how the displacement of the tennis ball varies with the square of time.

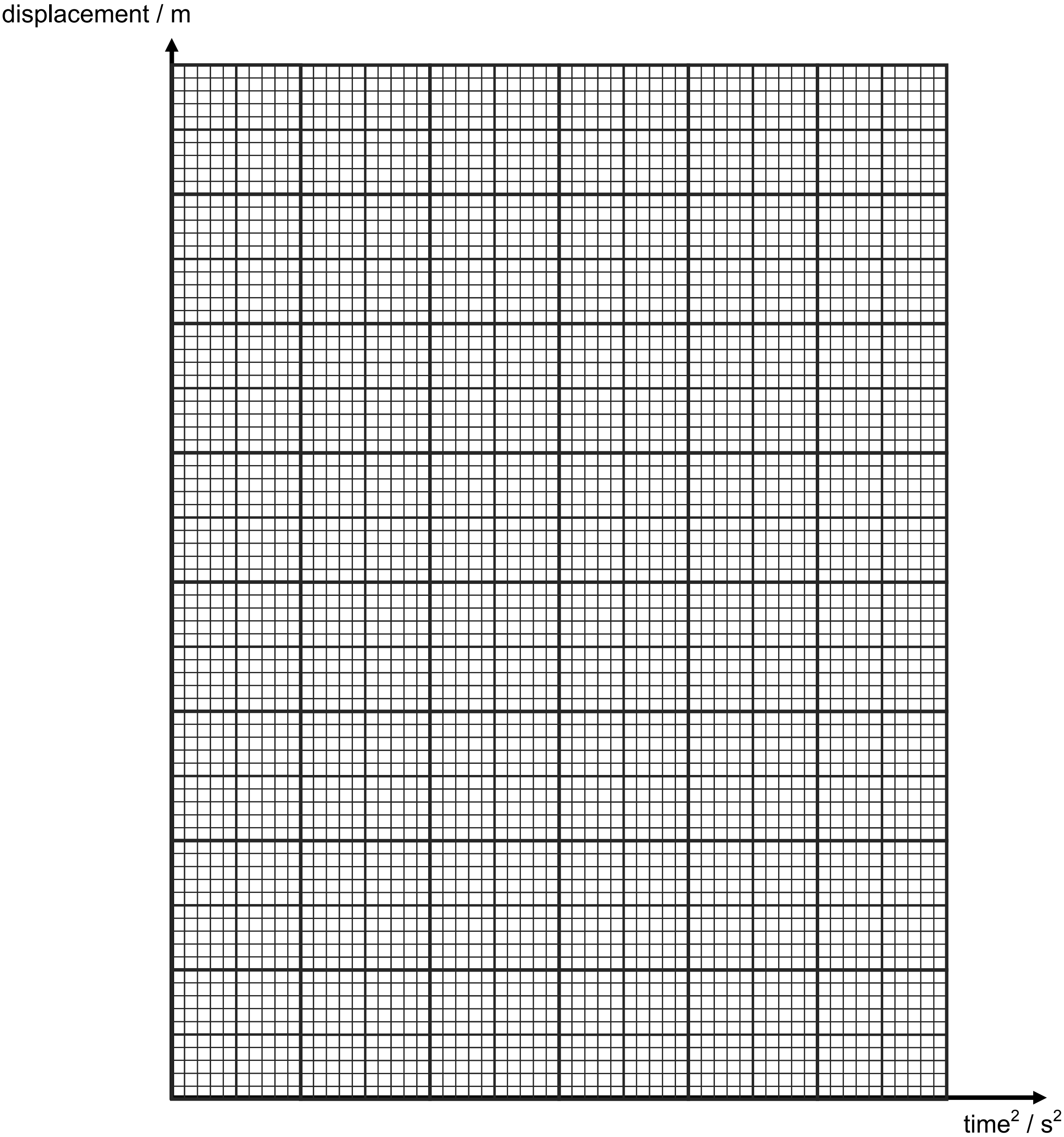
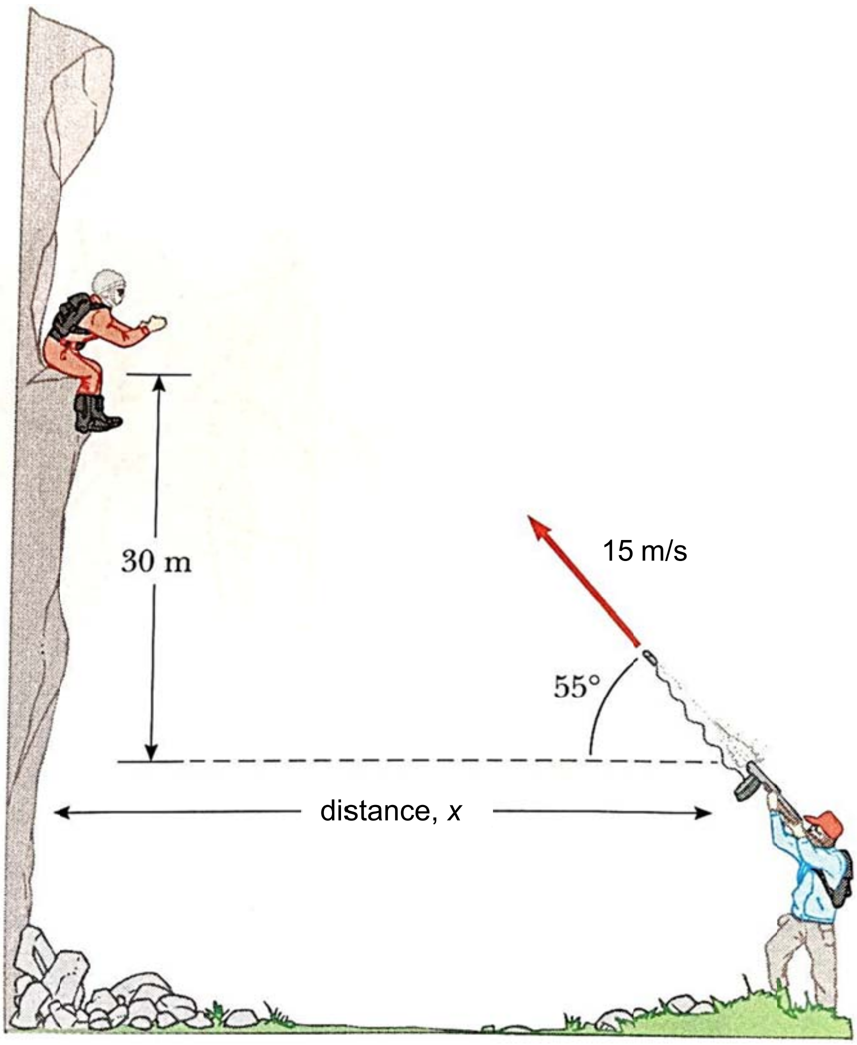


Fig. 6.2 [2]

(ii) Hence determine the acceleration of free fall on Planet Newtonia.

acceleration = …………………………………. m s^{-2} [2]

(c) During the space expedition on the Moon of Planet Newtonia, an astronaut is stranded on a ledge. The rescuer on the ground wants to shoot a projectile to him with a light rope attached to it. The projectile is directed at an initial angle of 55° and speed 15 m s^{-1}. The acceleration due to free fall on the Moon is 1.2 m s^{-2}.



(i) Determine the shortest possible time the rescuer needs to take to send the projectile to the astronaut.

time = ... s [2]

(ii) Hence, calculate how far the rescuer should stand in order for the projectile to land on the ledge.

distance = …………………………………. m [1]

(iii) Suggest how would your answer in **(c)(i)** change if the situation occurred on Planet Newtonia instead.

………………………………………………………………………………………..

……...…………………………………………………………………………….. [1]

Section B

Answer **two** questions in this section.

7 A series of data on the performance of one particular modern car are extracted from the manufacturer's handbook. The mass of car under test is 1400 kg. Study the following information in Fig. 7.1 to Fig 7.3 and answer the questions that follow.

Speed v / m s^{-1}	13.0	18.0	22.0	27.0	31.0	35.0	36.5
Time to reach that speed from rest t / s	3.5	5.0	7.0	10.0	13.5	19.5	28.0

Fig. 7.1 Time to reach the speed from rest

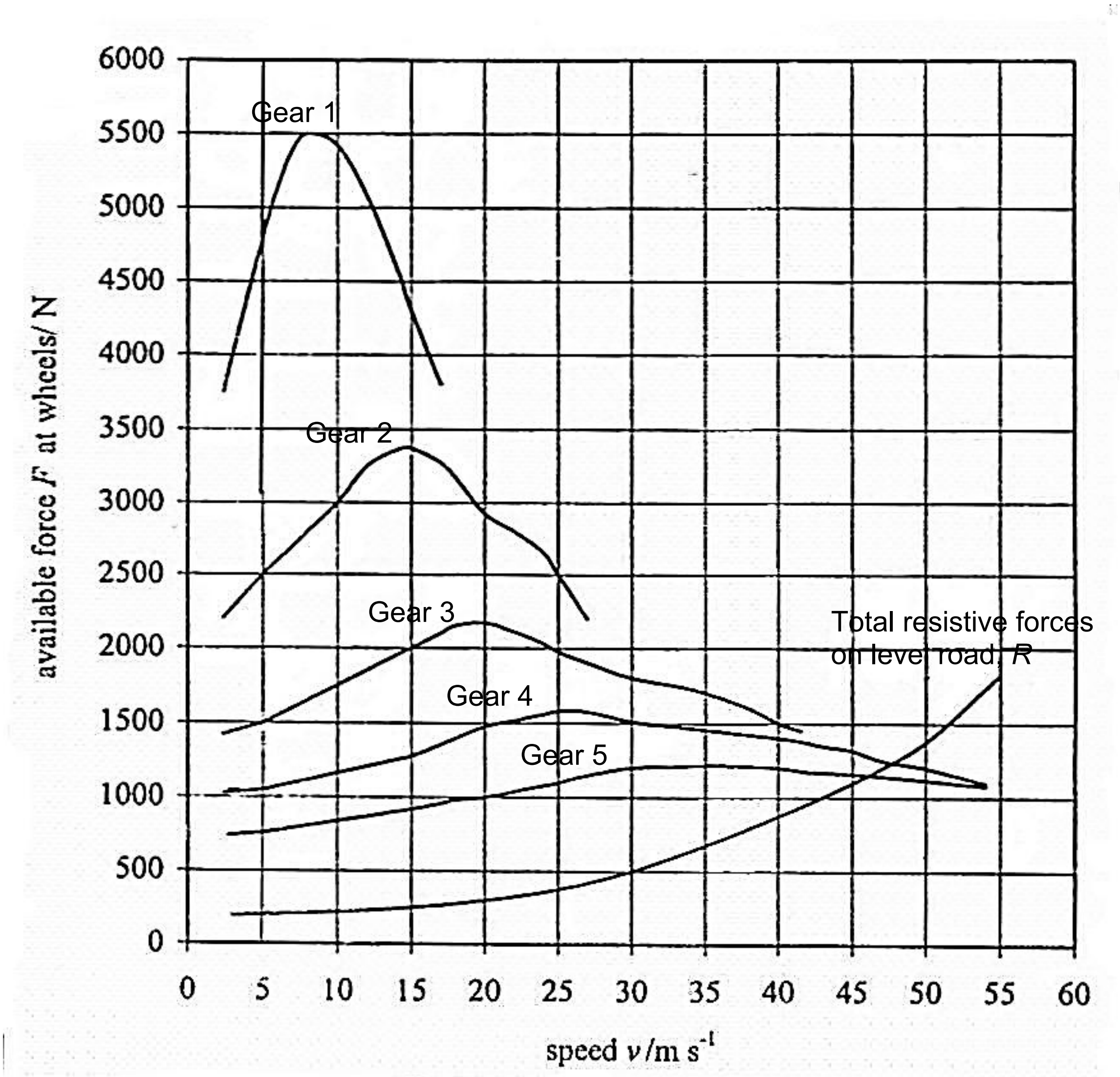


Fig. 7.2 Graphs of available force at the wheels (for different gears) and total resistive forces plotted against speed

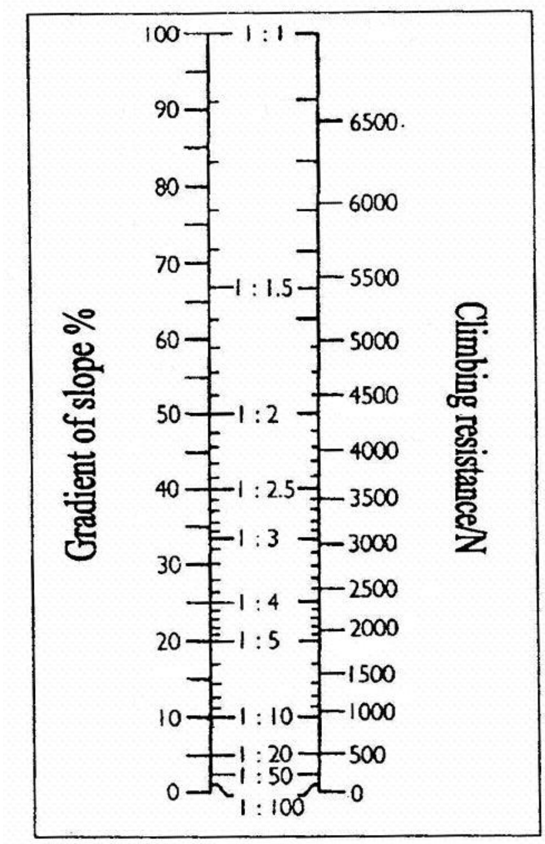


Fig. 7.3 Climbing resistance of the car on a particular slope

Note: A 10 % gradient means the slope rises 10 metres vertically for every 100 metres of horizontal distance.

(a) **(i)** On Fig. 7.4, plot a graph of speed *v* against time *t* for the car as it accelerates through the gears. [2]

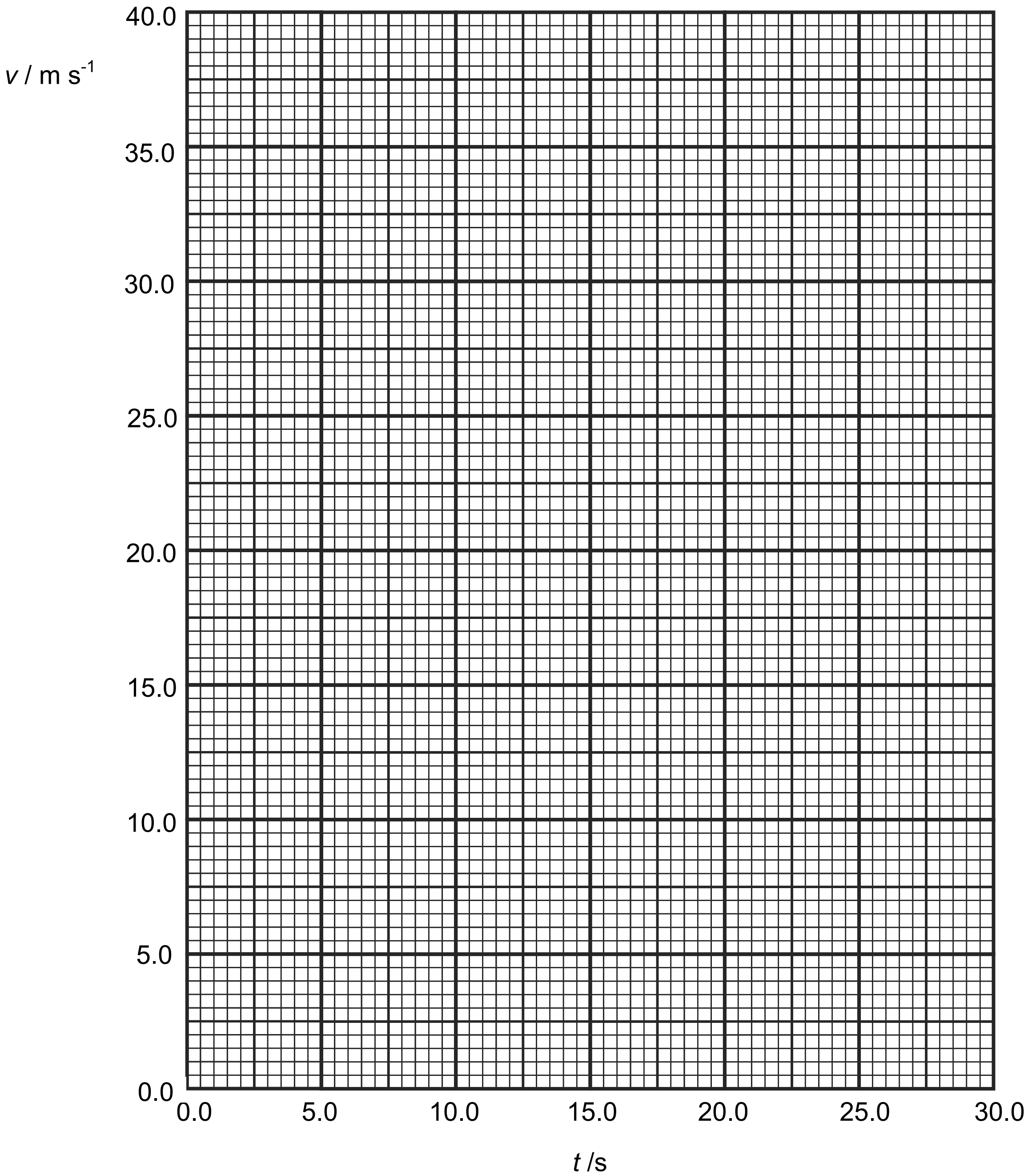


Fig. 7.4

(ii) From the above plot, determine the acceleration when the car is travelling at 25 m s^{-1}.

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

(b) Consider Fig. 7.2, which presents graphs of available force F at the wheels and the resistive forces R against speed v of the car travelling on a level road.

(i) Determine the optimum gear for maximum acceleration at 25 m s^{-1}. Justify your choice.

....

....

.... [2]

(ii) Calculate the maximum theoretical acceleration at 25 m s^{-1}.

maximum acceleration = ………………………………….. m s^{-2} [2]

(iii) Hence, comment on whether the information provided by the manufacturer is consistent.

....

.... [1]

(c) The total resistive force F_T to the car's motion on a slope is given by

$$F_T = R + F_S$$

where F_S is a constant climbing resistance on a particular slope.

By referring to Fig. 7.2 and Fig. 7.3, determine the maximum possible acceleration of the car on a 5 % slope at 15 m s^{-1}.

maximum acceleration = ………………………………….. m s^{-2} [3]

(d) **(i)** By referring to Fig. 7.2, calculate the power required from the engine if this car is to be maintained at a constant speed of 30 m s^{-1} on a level road.

power = ………………………………… W [2]

(ii) Determine the fuel consumption in the car's engine to provide this amount of power if the car travels for 1 hour. Assume that burning one litre of petrol releases 3.5×10^7 J, and the maximum energy conversion efficiency from the petrol combustion is 20 %.

fuel consumption = ………………………………… *l* [2]

(iii) Using your answer in **(d)(ii)**, calculate the distance that the car can travel on 1 litre of petrol.

distance travelled per litre of petrol = ………………………………… m l^{-1} [2]

(e) Fig. 7.5 shows the hydraulic braking system of the car.

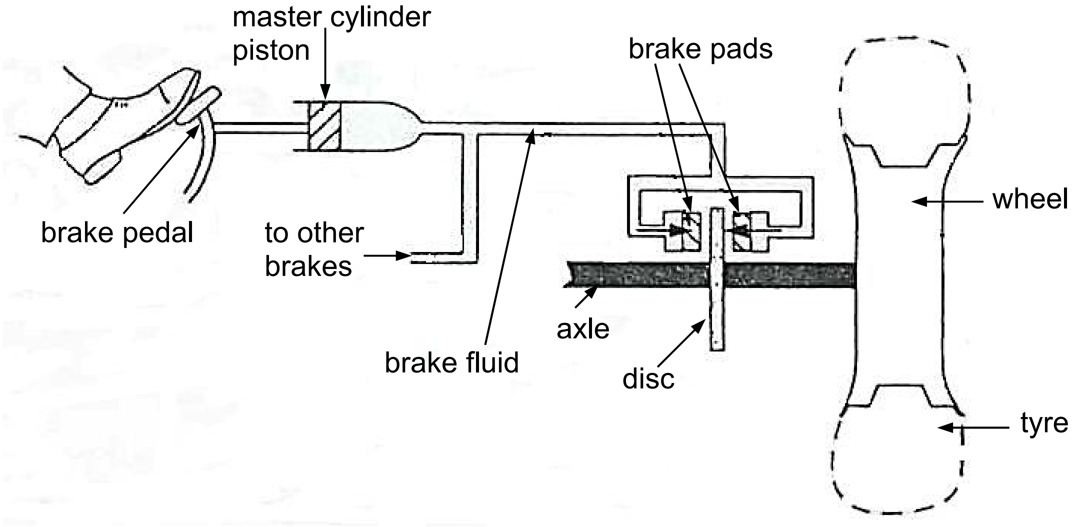


Fig. 7.5

Explain how a braking force is produced when the driver depresses the brake pedal with his foot.

....

....

....

.... [2]

8 An electric lamp is rated as 3.0 V, 0.60 W. The filament of the lamp is made from tungsten and is a wire of constant radius 4.0×10^{-5} m. The resistivity of tungsten at the normal operating temperature of the lamp is $7.9 \times 10^{-7}\ \Omega$ m.

(a) (i) Explain what information the rating "3.0 V, 0.60 W" provides about the normal operation of the lamp.

…. ………………………………………………………………………………………………….

……...………………………………………………………………………………………….. [1]

(ii) Show that the resistance of the filament is 15 Ω at normal operating temperature. [1]

(iii) Calculate the length of the filament.

length = ………………………………… m [3]

(iv) Comment on your answer to (a)(iii).

……...…………………………………………………………………………………………...

…. ………………………………………………………………………………………………….

……...………………………………………………………………………………………….. [1]

(b) The electric lamp is used in a circuit to measure its current-voltage (I-V) characteristics as shown in Fig. 8.1.

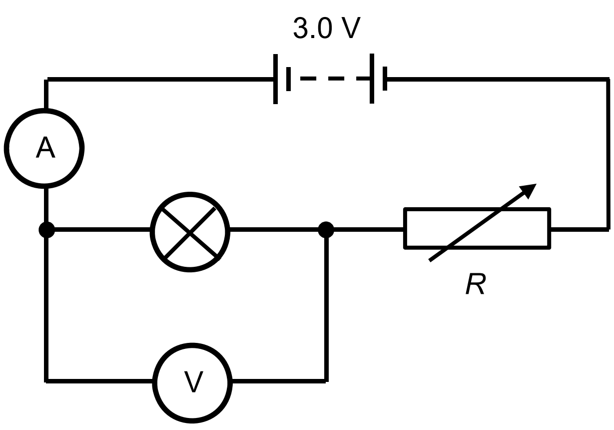


Fig. 8.1

When the variable resistor R is set to maximum value and zero value, the following ammeter and voltmeter readings were obtained:

Variable resistor setting	Ammeter reading	Voltmeter reading
Maximum	0.18 A	0.60 V
Zero	0.20 A	2.6 V

(i) Explain why, by changing the value of the resistance of the variable resistor, the potential difference across the lamp cannot be varied from 0 to 3.0 V.

……..……………………………………………………………………………………………...

…. ……………………………………………………………………………………………………

……..…………………………………………………………………………………………….. [2]

(ii) Determine the internal resistance of the battery.

resistance = ………………………………….. Ω [3]

(iii) Calculate the resistance of the filament when the reading on the voltmeter is

1. 0.60 V

resistance = ………………………………….. Ω [1]

2. 2.6 V

resistance = ………………………………….. Ω [1]

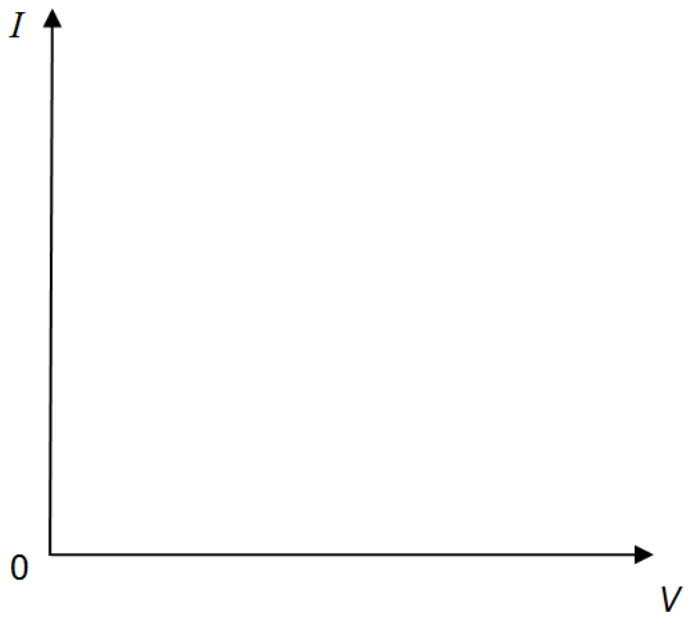
(iv) Explain why there is a difference between your answers to **(b)(iii)1** and **(b)(iii)2**.

……..………………………………………………………………………………………………...

…. ………………………………………………………………………………………………………

……..……………………………………………………………………………………………. [2]

(v) Using the axes below sketch the I-V characteristic of the filament of the lamp.



[1]

(vi) Fig. 8.2 below shows an alternative circuit for varying the potential difference across the lamp. A fixed resistor of 12 Ω is added to the circuit.

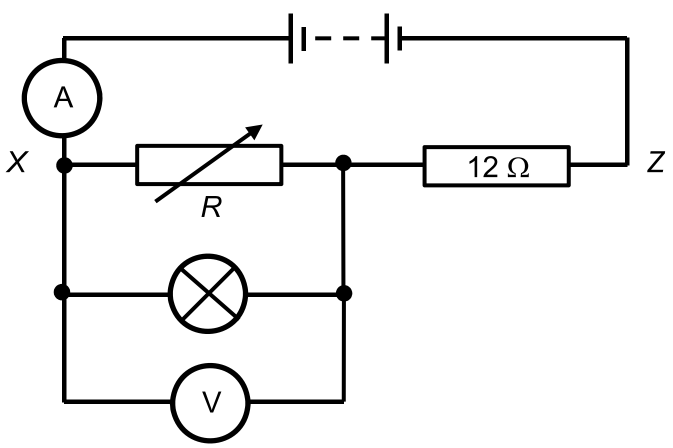


Fig. 8.2

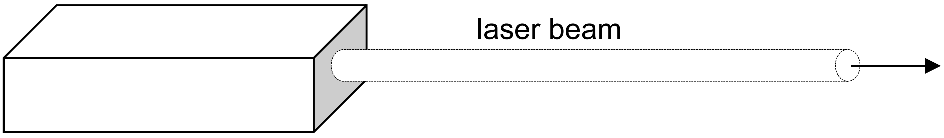
The potential difference across XZ is 3.0 V. The variable resistor R is set to have resistance of 12 Ω, equivalent to the resistance of the fixed resistor. The resistance of the lamp is 4.0 Ω.

.

Calculate the potential difference across the lamp.

potential difference = …………………………………. V [4]

9 **(a)** Waves from a monochromatic **laser** source are confined to a circular beam of diameter *d*.



If the laser radiates a total energy *E* in a time interval *t*, write an expression for the intensity of light at a distance of *x* from the source. [2]

(b) **(i)** Suggest two conditions for observable interference pattern.

……………………………………………………………………………………………………

……………………………………………………………………………………………………

…………………………………………………………………………………………………… [2]

(ii) The photograph shows the interference pattern produced when monochromatic light falls on a pair of slits 0.5 mm apart. The pattern was produced on a screen 1.5 m from the slits.

Explain why there is a bright fringe at the centre of the pattern.

……………………………………………………………………………………………………

……………………………………………………………………………………………………

……………………………………………………………………………………………………

……………………………………………………………………………………………………

…………………………………………………………………………………………………… [3]

(iii) The photograph has been enlarged by a factor of 3. Use the photograph to obtain a value for the fringe spacing.

fringe spacing = ………………………………… m [2]

(iv) Calculate the frequency of the light used.

frequency = ………………………………… Hz [3]

(v) Mark, with an X on the photograph, a fringe where light from one slit has travelled a distance of two wavelengths further than the light from the other slit. [1]

(vi) From the list below, circle all possible values of the phase difference between the two waves arriving at the centre of a dark region. [1]

$\frac{\pi}{2}$ π $\frac{3\pi}{2}$ 2π $\frac{5\pi}{2}$ 3π 4π 5π

(vii) Explain why the fringes nearer the centre of the photograph are clearer than those nearer the edges of the photograph.

……………………………………………………………………………………………………

……………………………………………………………………………………………………

……………………………………………………………………………………………………

……………………………………………………………………………………………………[2]

(viii) Explain how the pattern would be affected if (changes made separately)

1. light of longer wavelength were used.

……..………………………………………………………………………………………...

……..………………………………………………………………………………………...

……..………………………………………………………………………………………...

……..……………………………………………………………………………………[2]

2. one of the slits were covered completely.

……..………………………………………………………………………………………...

……..………………………………………………………………………………………...

……..………………………………………………………………………………………...

……..……………………………………………………………………………………[2]