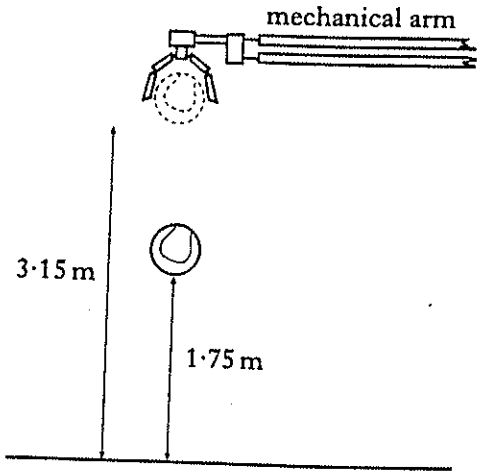
Errors Revision

Marks

1. The manufacturers of tennis balls require that the balls meet a given standard.
When dropped from a certain height onto a test surface, the balls must rebound to within a limited range of heights.
The ideal ball is one which, when dropped from rest from a height of 3·15 m, rebounds to a height of 1·75 m as shown below.



(*a*) Assuming air resistance is negligible, calculate

(i) the speed of an ideal ball just before contact with the ground

(ii) the speed of this ball just after contact with the ground. **3**

(*b*) When a ball is tested six times, the rebound heights are measured to be

1·71 m, 1·78 m, 1·72 m, 1·76 m, 1·73 m, 1·74 m.

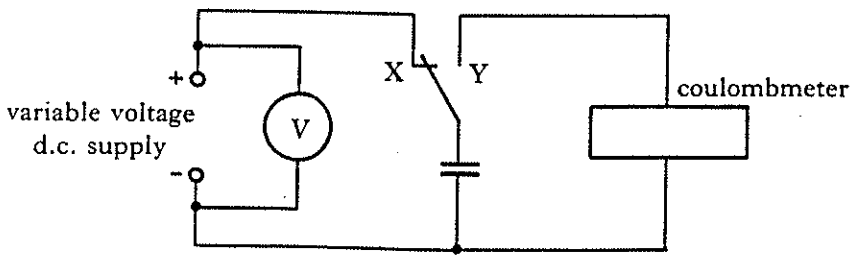
Calculate

(i) the mean value of the height of the bounce

(ii) the random error in this value. **3**

(6)

2. (*a*) The circuit shown below is used to find the capacitance of a capacitor.



With the switch in position X, the capacitor charges up to the supply voltage.
The reading on the voltmeter is noted and the switch is moved to position Y.
The coulombmeter then indicates the charge stored by the capacitor.

(i) One set of results is recorded below.

Voltmeter reading = 1·5 V
Coulombmeter reading = 24 μC.

Use these results to calculate a value for the capacitance of the capacitor.

(ii) The experiment is repeated with the **same** capacitor for five different values of the supply voltage, giving the following values for the capacitance.

Capacitance in μF = 16, 18, 20, 16, 15.

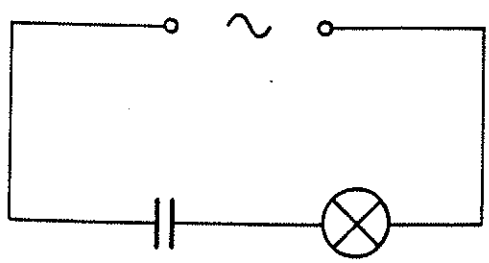
Using these five results, calculate the mean value for the capacitance **and** the approximate random error in this value.

[Turn over

(iii) How could the approximate random error in the mean value of the capacitance be reduced?

6

(*b*) The circuit below shows a capacitor connected to a lamp and a signal generator.



When the frequency of the signal generator is set at 100 Hz, the lamp glows.

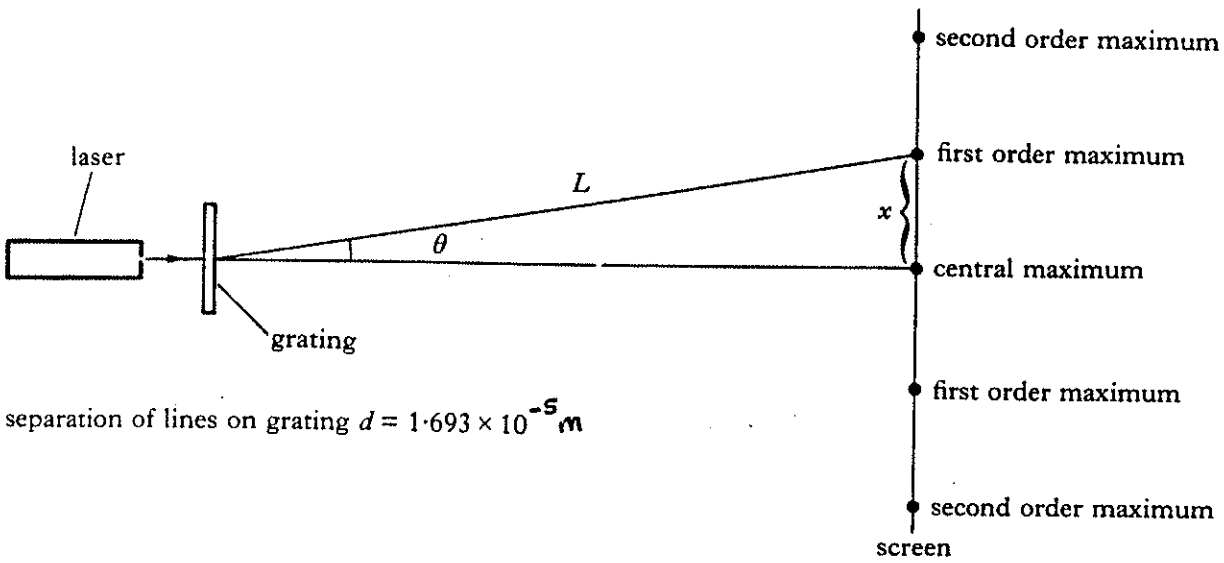
The frequency of the signal generator is now altered while the amplitude is kept constant. The lamp glows more brightly.

Explain this effect.

2

(8)

3. The apparatus shown below is set up to determine the wavelength of light from a laser.



separation of lines on grating $d = 1{\cdot}693 \times 10^{-5}$ m

The wavelength of the light is calculated using the equations

$$\lambda = d \sin\theta \quad \text{and} \quad \sin\theta = \frac{x}{L}$$

where angle θ and distances x and L are as shown in the diagram.

(*a*) Seven students measure the distance L with a tape measure.

Their results are as follows.

2·402 m	2·399 m	2·412 m	2·408 m
2·388 m	2·383 m	2·415 m	

Calculate the mean value for L **and** the approximate random error in the mean. 2

(*b*) The best estimate of the distance x is (91 ± 1) mm.

Show by calculation whether L or x has the larger percentage error. 2

(*c*) Calculate the wavelength, in nanometres, of the laser light.

You must give your answer in the form

final value ± error. 3

(*d*) Suggest an improvement which could be made so that a more accurate estimate of the wavelength could be made.

You must use only the same equipment and make the same number of measurements. 1

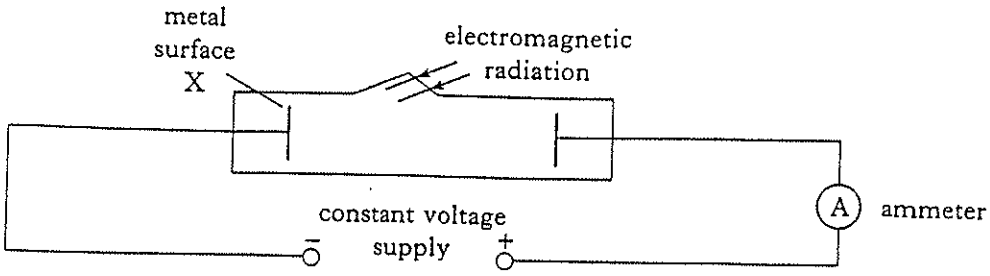
(8)

Optoelectronics Revision

Marks

1. (*a*) The apparatus shown below is used to investigate photoelectric emission from the metal surface X when electromagnetic radiation is shone on the surface.

The frequency of the electromagnetic radiation can be varied.

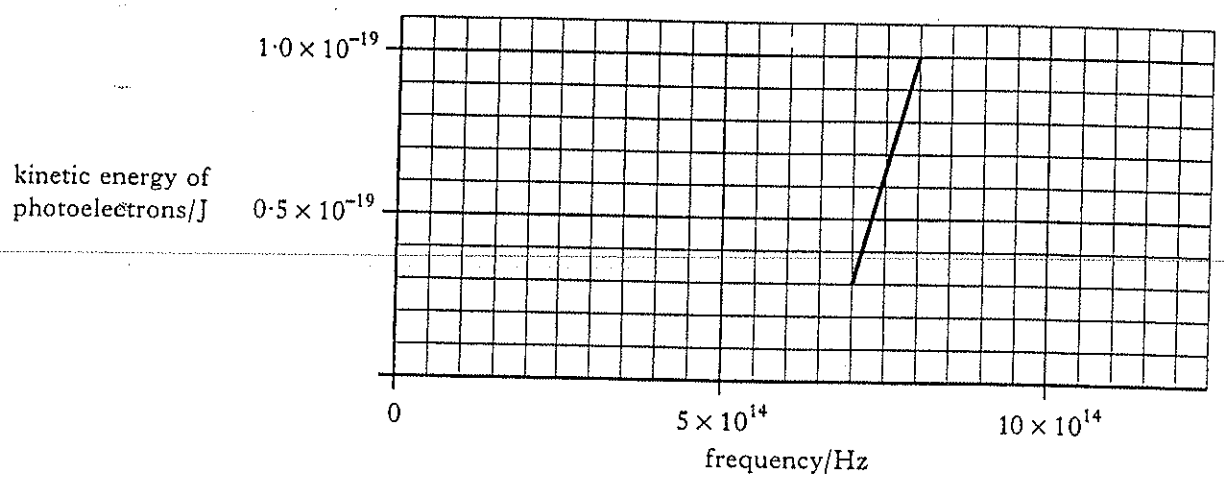


(i) When radiation of a certain frequency is shone on the metal surface X, a reading is obtained on the ammeter.
Sketch a graph to show how the current in the circuit varies with the irradiance of the radiation.

(ii) Explain why there is no reading on the ammeter when the frequency of the radiation is decreased below a particular value. 3

(*b*) The maximum kinetic energy of the photoelectrons emitted from metal X is measured for a number of different frequencies of the radiation.

The graph shows how this kinetic energy varies with frequency.



(i) Use the graph to find the threshold frequency for metal X.

(ii) The table below gives the work function of different metals.

Metal	*Work function/J*
Potassium	$3{\cdot}2 \times 10^{-19}$
Calcium	$4{\cdot}3 \times 10^{-19}$
Zinc	$6{\cdot}9 \times 10^{-19}$
Gold	$7{\cdot}8 \times 10^{-19}$

Which one of these metals was used in the investigation?
You must justify your answer using the information given in the table. 4

(7)

2. (*a*) The diagram below represents the p–n junction of a light emitting diode (LED).

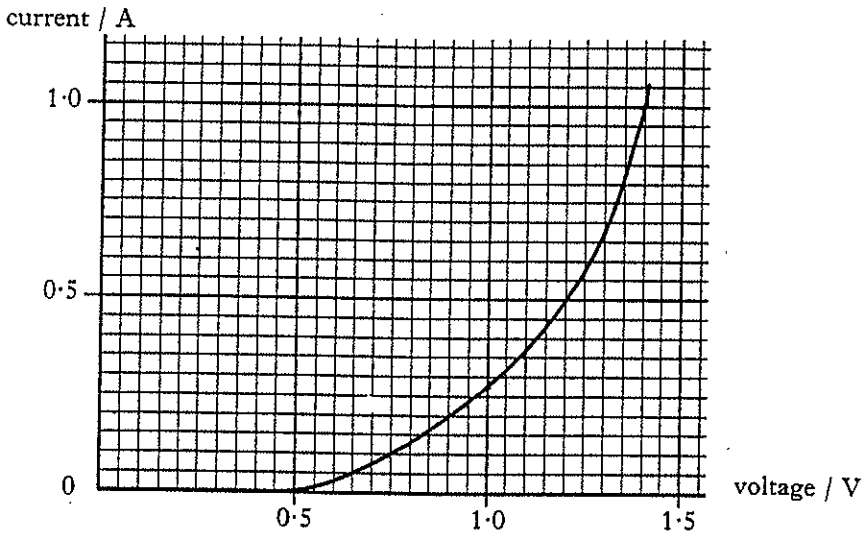
(i) Draw a diagram showing the above p–n junction connected to a battery so that the junction is forward biased.

(ii) When the junction is forward biased, there is a current in the diode. Describe the movement of the charge carriers which produces this current.

(iii) Describe how the charge carriers in the light emitting diode enable light to be produced.

5

(*b*) The following graph shows the variation of current with voltage for a diode when it is forward biased.



(i) What is the minimum voltage required for this diode to conduct?

(ii) What happens to the resistance of the diode as the voltage is increased above this minimum value?

Use information from the graph to justify your answer.

3

(8)

3. The word Laser is an acronym for "light amplification by the stimulated emission of radiation".

Describe what is meant by "stimulated emission" and describe how amplification is produced in a laser.

(3)

Radioactivity Revision

1. In investigating the effect of different types of radiation on the human body, the data in the table below was obtained for one particular type of body tissue. *Marks*

Radiation	*Absorbed Dose Rate*	Radiation Weighting Factor
γ-rays	$100\,\mu Gy\,h^{-1}$	1
Fast neutrons	$400\,\mu Gy\,h^{-1}$	10
α-particles	$50\,\mu Gy\,h^{-1}$	20

(*a*) Show, using the data in the table, which radiation is likely to be the most harmful to this tissue. 3

(*b*) (i) The maximum permitted equivalent dose for this tissue is 5 mSv. Calculate the time the tissue can be exposed to fast neutrons without exceeding this limit.

(ii) A sample of this tissue has a mass of 25 grams. How much energy will it absorb from fast neutrons in 2 hours? 5

(*c*) The effect of radiation on tissue can be reduced by putting shielding material between the source of radiation and the tissue. The effectiveness of this shielding material can be described by the half-value thickness of the material.

(i) Explain the meaning of "half-value thickness".

(ii) The half-value thickness for a particular material is 7 mm. A block of this material of thickness 3·5 cm is inserted between the source and the tissue.

What fraction of the radiation which is directed at the tissue is received by the tissue? 3

(11)

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2. The following statement represents a nuclear reaction which may form the basis of a nuclear power station of the future.

$$^{2}_{1}\mathrm{H} + {}^{3}_{1}\mathrm{H} \rightarrow {}^{4}_{2}\mathrm{He} + {}^{1}_{0}\mathrm{n}$$

(*a*) State the name given to the above type of nuclear reaction. 1

(*b*) Explain, using $E = mc^2$, how this nuclear reaction results in the production of energy. 2

(*c*) Using the information given below, and any other data required from the Data Sheet, calculate the energy released in the above nuclear reaction.

mass of $^{3}_{1}\mathrm{H}$ $= 5{\cdot}00890 \times 10^{-27}\,\mathrm{kg}$
mass of $^{2}_{1}\mathrm{H}$ $= 3{\cdot}34441 \times 10^{-27}\,\mathrm{kg}$
mass of $^{4}_{2}\mathrm{He}$ $= 6{\cdot}64632 \times 10^{-27}\,\mathrm{kg}$
mass of $^{1}_{0}\mathrm{n}$ $= 1{\cdot}67490 \times 10^{-27}\,\mathrm{kg}$ 3

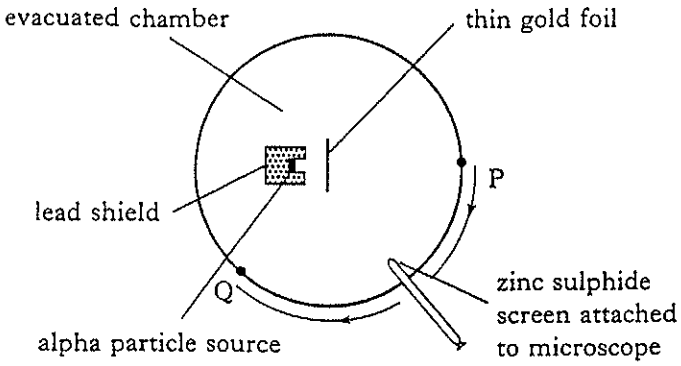
(*d*) Calculate how many of the reactions of the type represented above would occur each second to produce a power of 25 MW. 2

(8)

[Turn over

Marks

3. (*a*) The diagram shows the apparatus used by Rutherford to investigate the scattering of alpha particles by a gold foil.



From the observations made as the microscope and screen were moved from P to Q, Rutherford deduced that an atom has a nucleus which is:

(A) positively charged;

(B) massive;

(C) much smaller than the volume of the atom.

Explain how the observations from the scattering experiment led to these three deductions. 3

(*b*) A pupil reads in a textbook about the possible effects of a source of gamma rays and neutrons on one type of body tissue. A table in the textbook provided information relating to the radiations and absorbed doses for this body tissue. This table is shown below.

Type of radiation	Radiation Weighting Factor	*Absorbed dose*/μGy
gamma	1	200
neutrons	3	100

(i) Calculate the total equivalent dose received by the body tissue.

(ii) Calculate the thickness of lead which would have to surround the above source to reduce the absorbed dose from the gamma rays to 25 μGy.

The half-value thickness of lead for the gamma radiation is 8 mm. 5

(8)

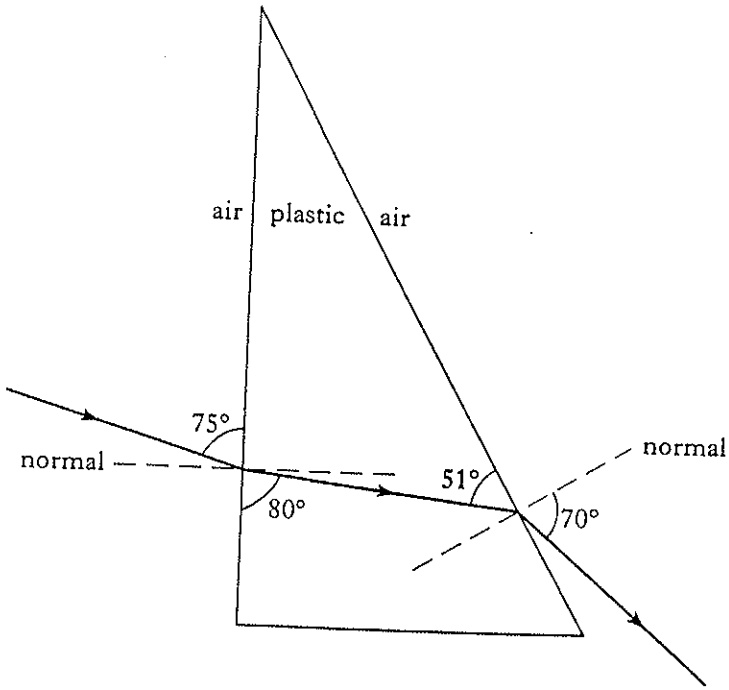
4. A possible nuclear reaction involving $^{235}_{92}U$ is represented by the following statement.

$$^{235}_{92}U + {}^{1}_{0}n = {}^{98}_{42}Mo + {}^{136}_{y}Xe + 2\,{}^{1}_{0}n + 4\,{}^{0}_{-1}e$$

(i) The symbol for the uranium nucleus is $^{235}_{92}U$. What information about the particles in the nucleus is provided by the numbers 92 and 235?

(ii) Determine the number represented by *y*. (3)

1. (*a*) The diagram below shows the refraction of a ray of red light as it passes through a plastic prism. *Marks*

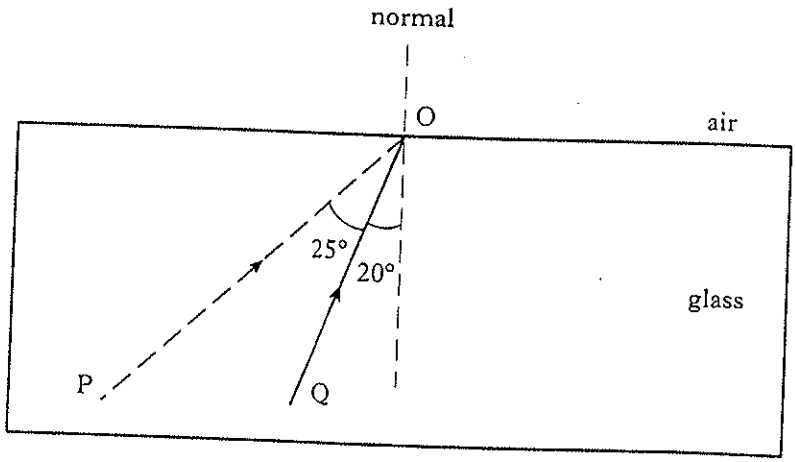


Calculate the refractive index of the plastic for this red light. 2

(*b*) The refractive index of a glass block is found to be 1·44 when red light is used.

(i) What is the value of the critical angle for this red light in the glass?

(ii) The diagram shows the paths of two rays of this red light, PO and QO, in the glass block.



When rays PO and QO strike the glass-air boundary, **three** further rays of light are observed.

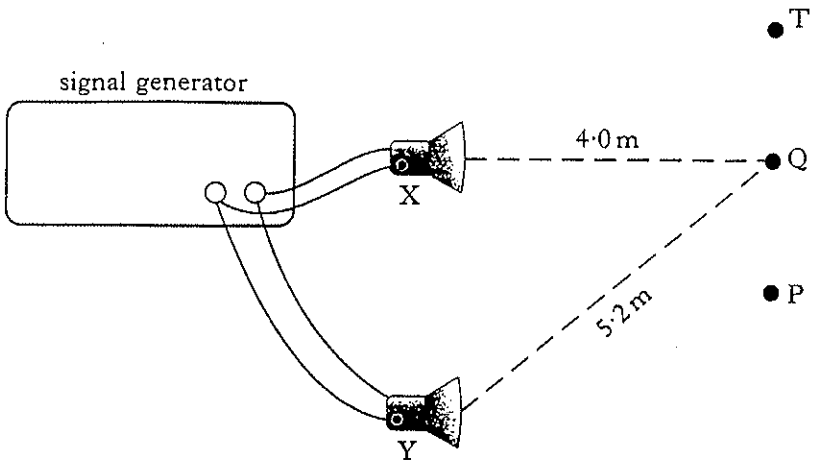
Copy and complete the diagram to show **all five** rays.

Clearly indicate which of the three rays came from P and which came from Q.

The values of all angles should be shown on the diagram. 6

(8)

2. Two identical loudspeakers X and Y are set up in a room which has been designed to eliminate the reflection of sound. The loudspeakers are connected to the same signal generator as shown.



(*a*) (i) When a sound level meter is moved from P to T, maxima and minima of sound intensity are detected.

Explain, in terms of waves, why the maxima and minima are produced.

(ii) The sound level meter detects a maximum at P.

As the sound level meter is moved from P, it detects a minimum then a maximum then another minimum when it reaches Q.

Calculate the wavelength of the sound used. **4**

(*b*) The sound level meter is now fixed at Q.

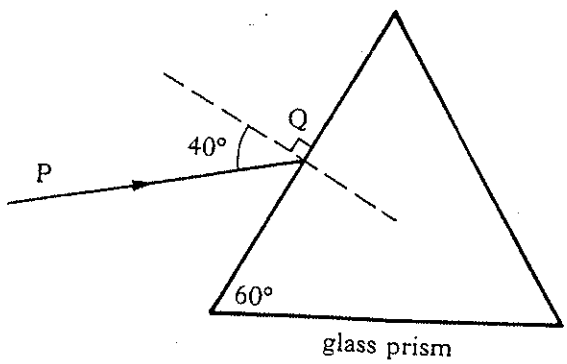
The frequency of the output from the signal generator is increased steadily from 200 Hz to 1000 Hz.

(i) What happens to the wavelength of the sound as the frequency of the output is increased?

(ii) Explain why the sound level meter detects a series of maxima and minima as the frequency of the output is increased. **3**

(7)

3. A beam of monochromatic light passes into a glass prism of refractive index 1.80 as shown.



(i) Calculate the critical angle for this glass.

(ii) Draw an accurate diagram, showing the passage of the ray PQ through this prism until after it emerges into the air.

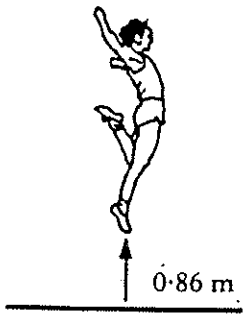
Mark on your diagram the values of all relevant angles. **(5)**

Kinematics Revision Questions

Marks

1. (*a*) A long jumper devises a method for estimating the horizontal component of his velocity during a jump.

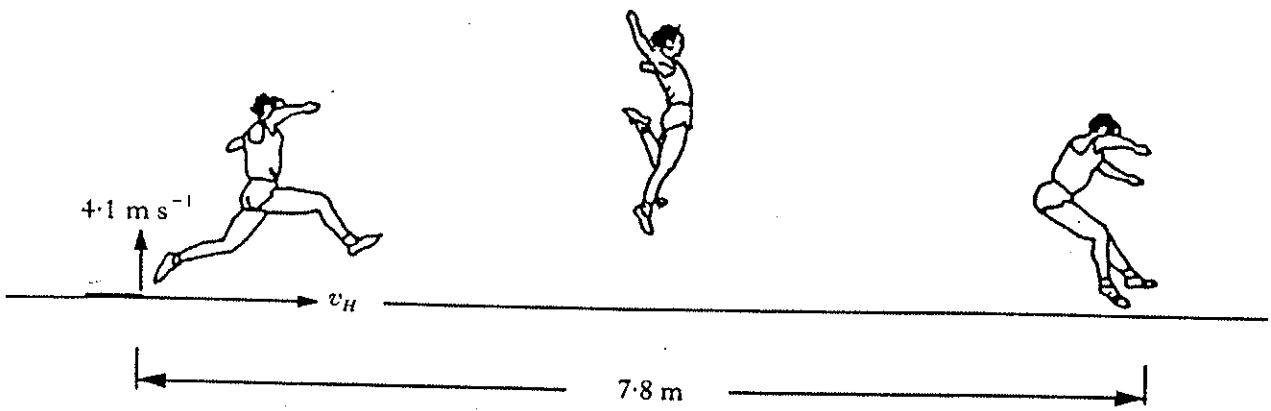
His method involves first finding out how high he can jump **vertically**.



He finds that the maximum height he can jump is 0·86 m.

(i) Show that his initial vertical velocity is 4·1 m s^{-1}.

He now assumes that when he is long jumping, the initial vertical component of his velocity at take-off is 4·1 m s^{-1}.



The length of his long jump is 7·8 m.

(ii) Calculate the value that he should obtain for the horizontal component of his velocity, v_H. **5**

(*b*) His coach tells him that, during the 7·8 m jump, his maximum height above the ground was less than 0·86 m. Ignoring air resistance, state whether his actual horizontal component of velocity was greater or less than the value calculated in part (*a*) (ii). You must justify your answer. **2**

(7)

2. A rocket-propelled vehicle carrying a dummy is used at a research centre to test the ejection seat for a jet aircraft as shown in the diagram.

The vehicle and dummy have a combined mass of 500 kg. The rocket engines increase the kinetic energy of the vehicle by 2·80 × 10^7 J for each kilogram of fuel used.

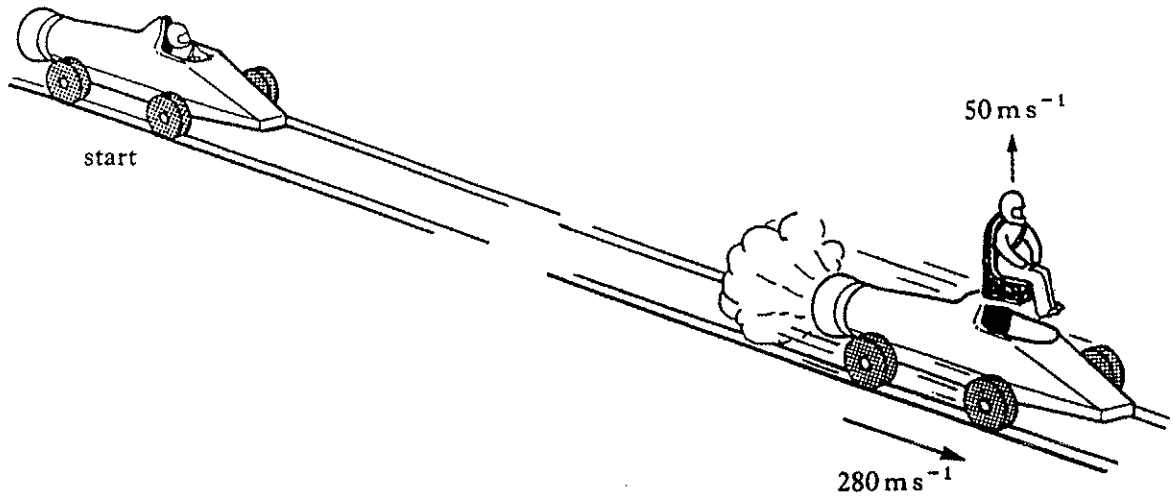
In a test run, the vehicle accelerates **from rest** along the track until 0·70 kg of fuel is used up.

(*a*) (i) Show that the maximum possible speed reached by the vehicle is 280 m s^{-1}. You may ignore the effect of friction.

(ii) The dummy is ejected when the vehicle reaches a speed of 280 m s^{-1} after 8·0 s.

Calculate how far the vehicle is from the start when the dummy is ejected. Assume that the acceleration of the vehicle is constant during the 8·0 s test run. **5**

[Turn over



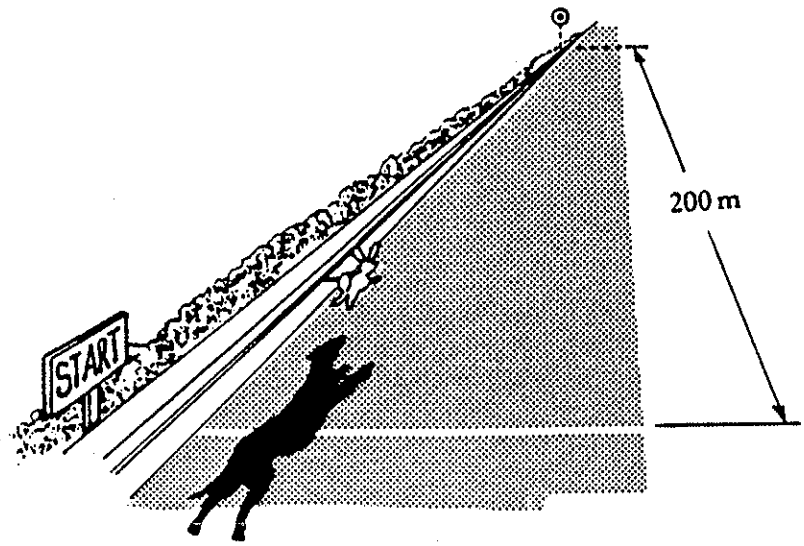
(*b*) The dummy is ejected at the instant the vehicle reaches a horizontal velocity of 280 m s^{-1}. The ejection seat being tested projects the dummy upwards with an initial vertical velocity of 50 m s^{-1}.

(i) Describe and explain the path taken by the dummy after its ejection from the vehicle.

(ii) Calculate the maximum height reached by the dummy. You may ignore the effect of friction. **4**

(9)

3. An artificial hare travels along a straight section of track at a constant speed of 14 m s^{-1}.



A dog with a reaction time of 0·4 s is released at the instant the hare passes the starting line. The dog accelerates at a constant rate for 2·5 s and reaches a speed of 15 m s^{-1}. This speed is maintained for 7·5 s, after which the dog begins to decelerate at a rate of 0·5 m s^{-2} until it has covered 200 m.

(*a*) Calculate the distance the dog has run, up to the instant at which it starts to decelerate. **2**

(*b*) Calculate:

(i) the speed of the dog at the 200 m mark;

(ii) the time the dog takes to cover this distance. **5**

(*c*) Using squared-ruled paper, draw an accurate acceleration–time graph for the motion of the dog from the time of release until it covers 200 m. **3**

(*d*) Explain whether or not the dog catches the hare before the 200 m mark. **1**

(11)

Marks

1. During a test on car safety, two cars as shown below are crashed together on a test track.

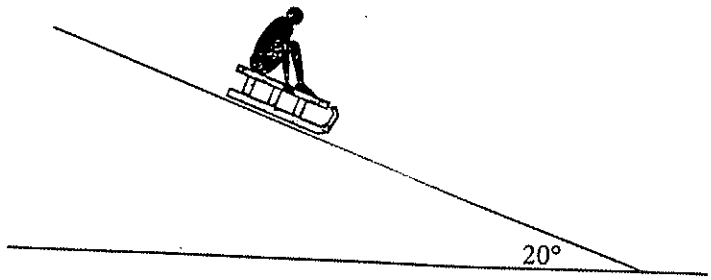
(*a*) Car A, which has a mass of 1200 kg and is moving at 18·0 m s^{-1}, approaches car B, which has a mass of 1000 kg and is moving at 10·8 m s^{-1}, in the opposite direction.

The cars collide head on, lock together and move off in the direction of car A.

(i) Calculate the speed of the cars immediately after the collision.

(ii) Show by calculation that this collision is inelastic. **4**

2. A child on a sledge slides down a slope which is at an angle of 20° to the horizontal as shown below.



The combined weight of the child and the sledge is 400 N. The frictional force acting on the sledge and child at the start of the slide is 20·0 N.

(*a*) (i) Calculate the component of the combined weight of the child and sledge down the slope.

(ii) Calculate the initial acceleration of the sledge and child. **4**

(*b*) The child decides to start the slide from further up the slope. Explain whether or not this has any effect on the initial acceleration. **2**

(*c*) During the slide, the sledge does not continue to accelerate but reaches a constant speed. Explain why this happens. **2**

(8)

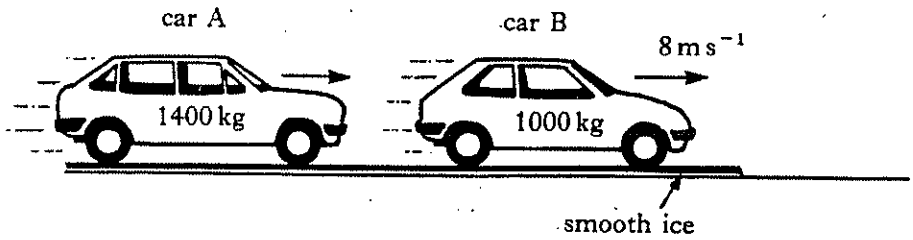
Marks

3. (*a*) State the law of conservation of linear momentum as it applies to a collision between two objects. **1**

(*b*) Two cars, travelling in the same direction, skid on a patch of smooth, level ice.

Car A, of mass 1400 kg, skids straight into the back of car B, of mass 1000 kg.

The two cars become entangled after the impact and continue to move in the same straight line.



Immediately before the impact, car B is moving with a speed of $8\,m\,s^{-1}$.

Immediately after the impact, both cars are moving with a speed of $15\,m\,s^{-1}$.

(i) Calculate the speed of car A just before the collision takes place.

(ii) After the collision, the cars leave the patch of ice and continue skidding along the road. They come to rest in a distance of 20 metres after leaving the ice.

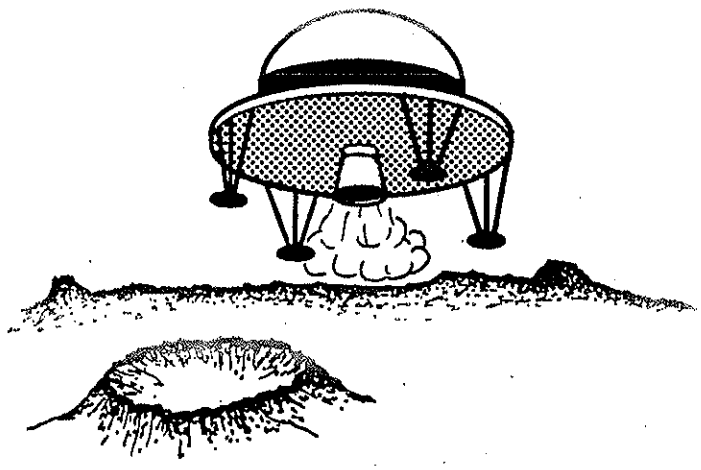
Calculate the average frictional force acting on the cars as they come to rest.

(iii) State what happens to the kinetic energy of the cars after they leave the ice. **7**

(8)

4. A lunar landing craft descends vertically towards the surface of the Moon with a constant speed of $2{\cdot}0\,m\,s^{-1}$. The craft and crew have a total mass of 15 000 kg.

Assume that the gravitational field strength on the Moon is $1{\cdot}6\,N\,kg^{-1}$.



(*a*) During the first part of the descent the upward thrust of the rocket engine is 24 000 N. Show that this results in the craft moving with a constant speed. **2**

(*b*) The upward thrust of the engine is increased to 25 500 N for the last 18 seconds of the descent.

(i) Calculate the deceleration of the craft during this time.

(ii) What is the speed of the craft just before it lands?

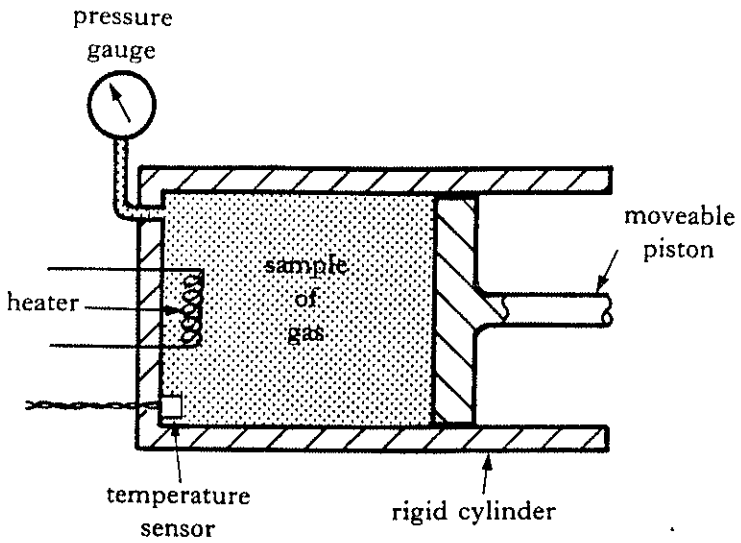
(iii) How far is the craft above the surface of the Moon when the engine thrust is increased to 25 500 N? **7**

(9)

Properties of Matter Revision Questions

Marks

1. A pupil uses the apparatus below to investigate properties of a sample of gas.

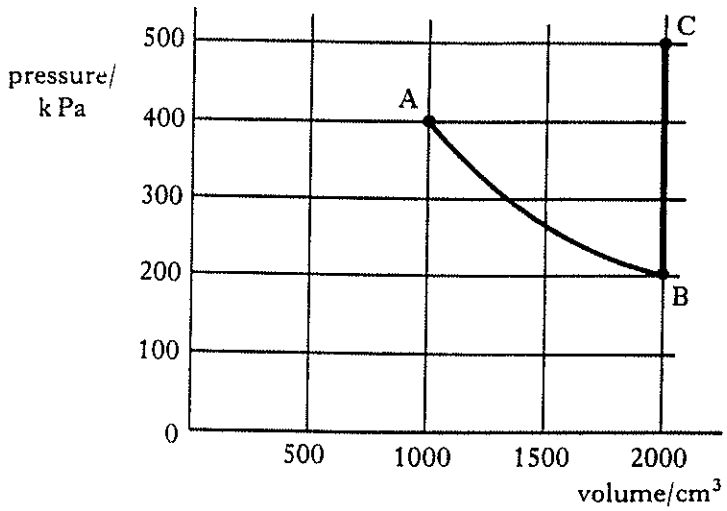


The volume of the sample of gas can be changed by moving the piston.

The temperature of the sample of gas can be increased by using the heater.

At the start, the pressure of the gas is 400 kPa and its volume is 1000 cm^3.

During the investigation, the pressure and volume of the gas change as indicated by sections AB and BC on the graph below.



During section AB, the temperature of the gas is constant at 300 K.

(*a*) **Calculate** the volume of the gas when its pressure is 250 kPa during stage AB. **2**

(*b*) State what happens to the pressure, volume and temperature of the gas over the section of the graph which starts at B and finishes at C. **2**

(*c*) What is the temperature of the gas, in kelvin, corresponding to point C on the graph? **2**

(6)

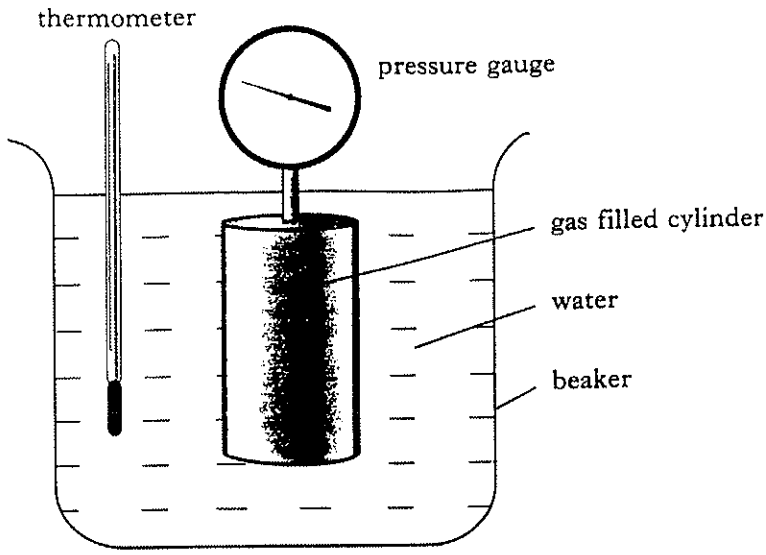
2. A pupil uses the apparatus shown in the diagram to investigate the relationship between the pressure and the temperature of a fixed mass of gas at constant volume.

The cylinder is fully immersed in a beaker of water and the water is slowly heated.

You may assume that the volume of the cylinder does not change as the temperature of the water changes.

(*a*) Explain why the cylinder must be fully immersed in the beaker of water. **1**

[Turn over



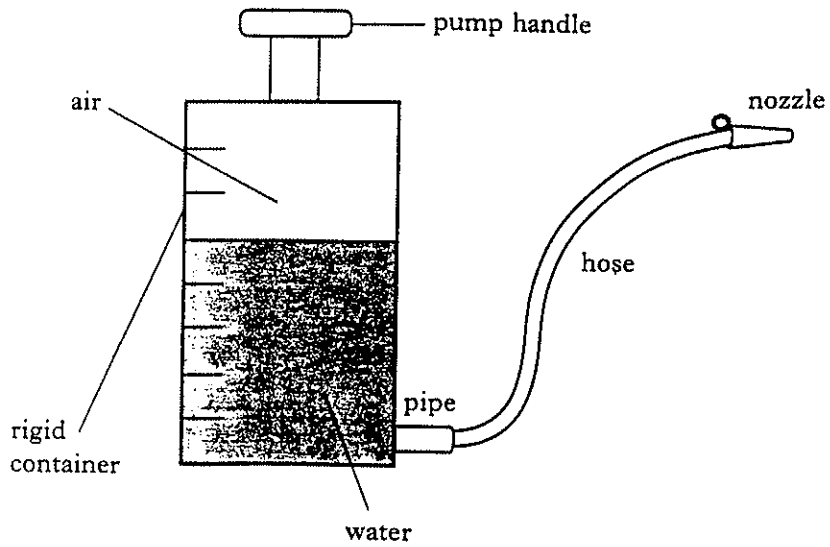
(*b*) The pressure of the gas in the cylinder is 100 kPa when the gas is at a temperature of 17 °C. Calculate the pressure of the gas in the cylinder when the temperature of the gas is 75 °C. **2**

(*c*) The base of the cylinder has an area of $0{\cdot}001\ m^2$. What is the force exerted by the gas on the base when the temperature of the gas is 75 °C? **2**

(*d*) What happens to the density of the gas in the cylinder as the temperature increases from 17 °C to 75 °C?
Justify your answer. **2**

(7)

3. The rigid container of a garden sprayer has a total volume of 8·0 litres ($8 \times 10^{-3}\ m^3$). A gardener pours 5·0 litres ($5 \times 10^{-3}\ m^3$) of water into the container. The pressure of the air inside the container is $1{\cdot}01 \times 10^5$ Pa.



(*a*) Calculate the mass of air in the sprayer. Use information from the data sheet. **3**

(*b*) The gardener now pumps air into the container until the pressure of the air inside it becomes $3{\cdot}0 \times 10^5$ Pa.

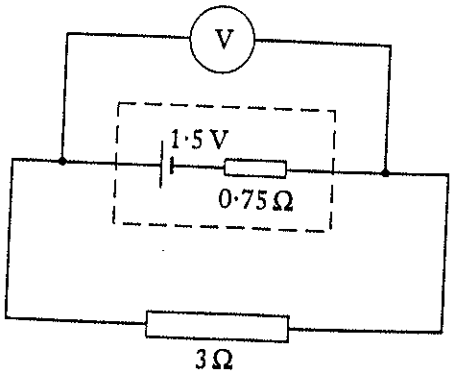
(i) The area of the water surface in contact with the compressed air is $7{\cdot}0 \times 10^{-3}\ m^2$. Calculate the force which the compressed air exerts on the water.

(ii) Water is now released through the nozzle. Calculate the final pressure of the air inside the sprayer when the volume of water falls from 5·0 litres ($5 \times 10^{-3}\ m^3$) to 2·0 litres ($2 \times 10^{-3}\ m^3$).
Assume the temperature of the compressed air remains constant. **4**

(7)

Resistors in Circuits Revision Questions

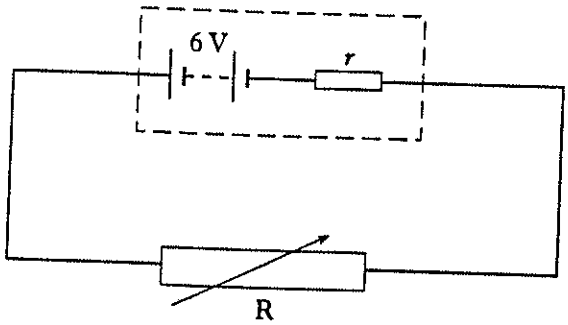
1. (*a*) A cell of e.m.f. 1·5 V and internal resistance 0·75 Ω is connected as shown in the following circuit. *Marks*



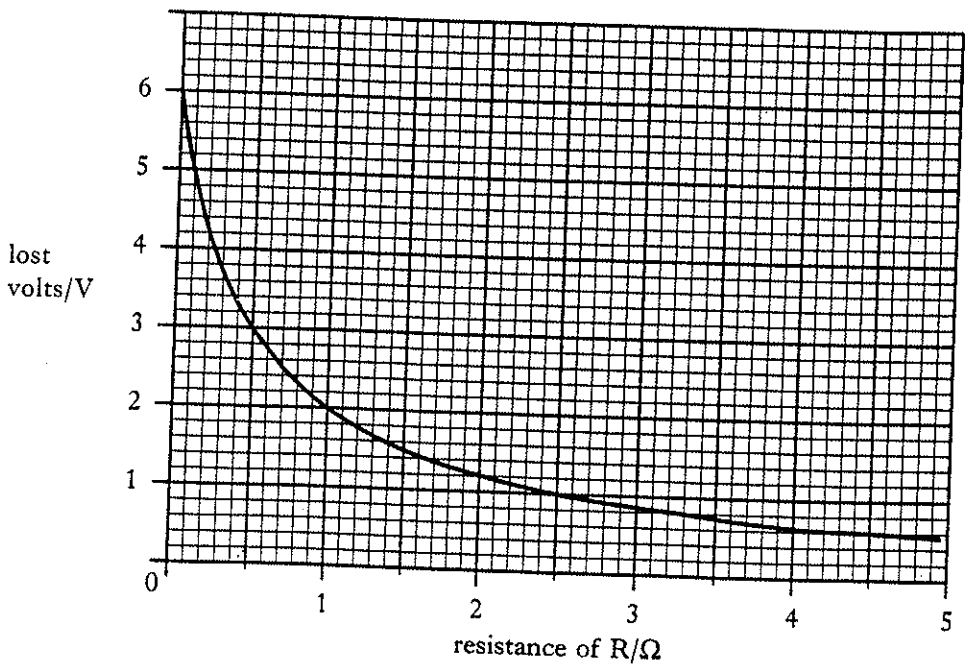
(i) Calculate the value of the reading on the voltmeter.

(ii) What is the value of the "lost volts" in this circuit? **5**

(*b*) A battery of e.m.f. 6 V and internal resistance, *r*, is connected to a variable resistor R as shown in the following circuit diagram.



The graph below shows how the "lost volts" of this battery changes as the resistance of R increases.



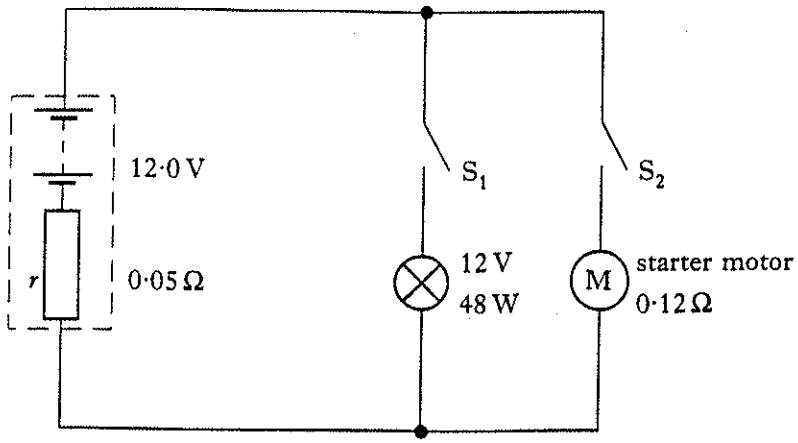
(i) Use information from the graph to calculate the p.d. across the terminals of the battery (t.p.d.) when the resistance of R is 1 Ω.

(ii) Calculate the internal resistance, *r*, of the battery.

[Turn over **4**

(9)

2. The diagram shows a circuit for part of the electrical system of a car.



The battery has an e.m.f. of 12·0 V and an internal resistance r of 0·05 Ω. The battery is connected across a 12 V, 48 W headlamp and a starter motor of resistance 0·12 Ω as shown.

(*a*) State what is meant by "the battery has an e.m.f. of 12·0 V". **1**

(*b*) (i) What is the resistance of the headlamp when used at its rated voltage?

(ii) Show that there is a p.d. of 11·8 V across the headlamp when switch S_1 is closed and switch S_2 is open. Assume that the resistance of the headlamp does not change. **4**

(*c*) Both switches S_1 and S_2 are now closed.

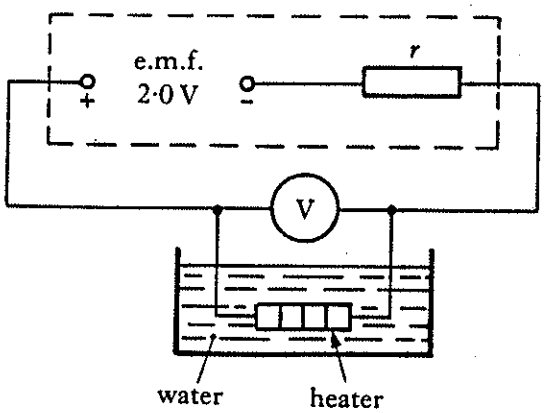
Assuming that the resistance of the headlamp does not change, calculate:

(i) the total resistance of the circuit;

(ii) the current from the battery. **4**

(9)

3. A heater of resistance 0·32 ohms is connected to a power supply of e.m.f. 2·0 volts and internal resistance r as shown below.



(*a*) State what is meant by the term electromotive force (e.m.f.). **1**

(*b*) The power output of the **heater** is 8·0 watts.

Calculate:

(i) the current in the heater;

(ii) the reading on the voltmeter;

(iii) the internal resistance of the power supply. **5**

(*c*) Another identical heater is now placed in the water and connected in parallel with the original heater.

The rest of the circuit is unaltered.

How does this affect the rate at which heat is supplied to the water?

Justify your answer by calculation. **3**

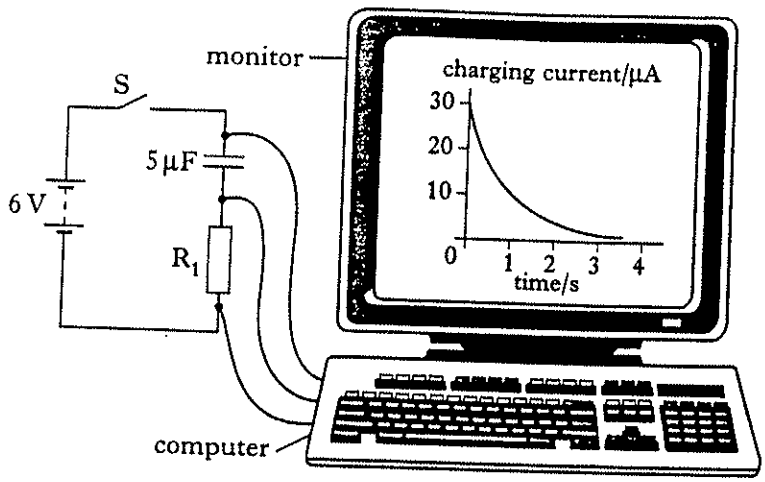
(9)

AC and Capacitance Revision Questions

Marks

1. (*a*) A capacitor has a value of 5 μF. Explain in terms of electric charge what this means. **1**

(*b*) The 5 μF capacitor shown in the circuit below is initially uncharged. The circuit is connected to a computer and switch S is closed. The monitor of the computer displays a graph of current against time as the capacitor charges.



The battery has negligible internal resistance.

(i) Calculate the resistance of R_1.

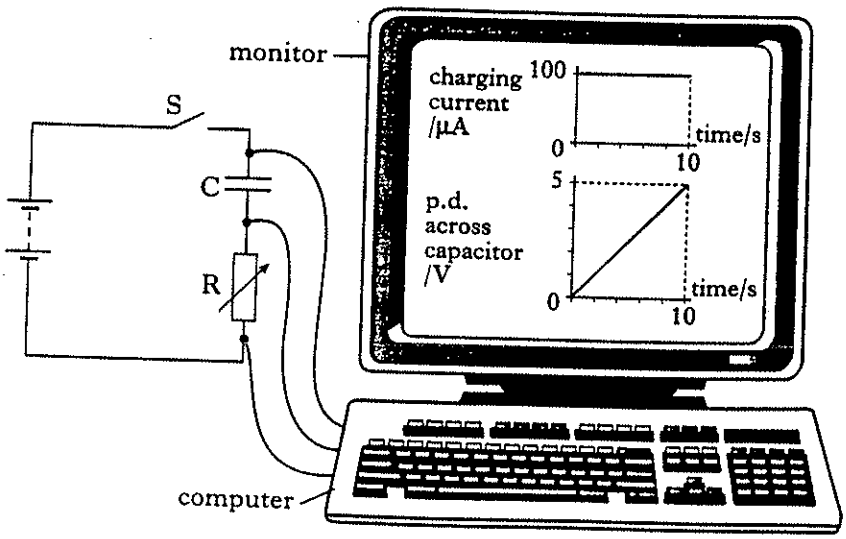
(ii) The resistor R_1 is replaced by another resistor R_2. The resistance of R_2 is half that of R_1.

The capacitor is discharged and the experiment repeated.

Sketch the graph of charging current against time when R_2 is used. Include values on the axes.

3

(*c*) In the following circuit a variable resistor R is used to keep the current constant as a different capacitor charges. The graphs on the monitor show how the charging current and p.d. across the capacitor vary with time after switch S is closed.



(i) What adjustment must be made to the variable resistor R so that a constant charging current is produced?

(ii) Show by calculation that 10 seconds after switch S is closed, the charge on the capacitor is 1mC.

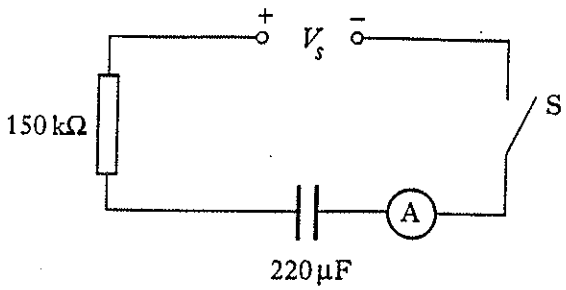
(iii) Calculate the capacitance of C.

4

(8)

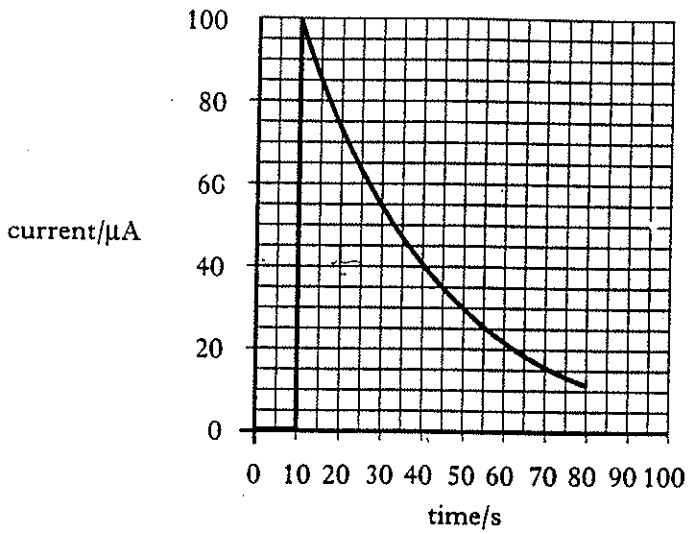
Marks

2, (*a*) A capacitor of capacitance 220 μF is connected in series with a 150 kΩ resistor, a switch and an ammeter. A d.c. power supply of negligible internal resistance is connected to the circuit as shown below.



A stopclock is started and after 10 seconds the switch S is closed. Ammeter readings are noted at regular intervals until a time of 80 s is shown on the stopclock.

The graph below shows how the current in the circuit varies with time.



- (i) Calculate the voltage V_s of the d.c. power supply.
- (ii) At what time on the stopclock does the p.d. across the resistor equal 6 V?
- (iii) What is the p.d. across the capacitor when the p.d. across the resistor is 6 V? **5**

(*b*) A magazine article on the resuscitation of a heart attack victim describes the equipment used. This equipment uses a 16 μF capacitor which is charged until the p.d. across it is 6 kV. The capacitor is then fully discharged to give the heart a shock. The discharge time is 2 ms.

(i) When the capacitor is fully charged, calculate:

(A) the charge stored;

(B) the energy stored.

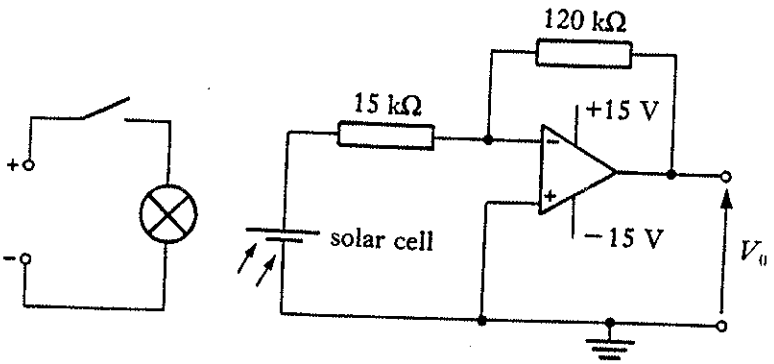
- (ii) Calculate the average current during discharge. **6**

(11)

Analogue Electronics Revision Questions

Marks

1. (*a*) In order to compare the brightness of a number of low voltage lamps, a solar cell is used to detect the light from the lamps. An operational amplifier, working in the inverting mode, is used to amplify the solar cell voltage.

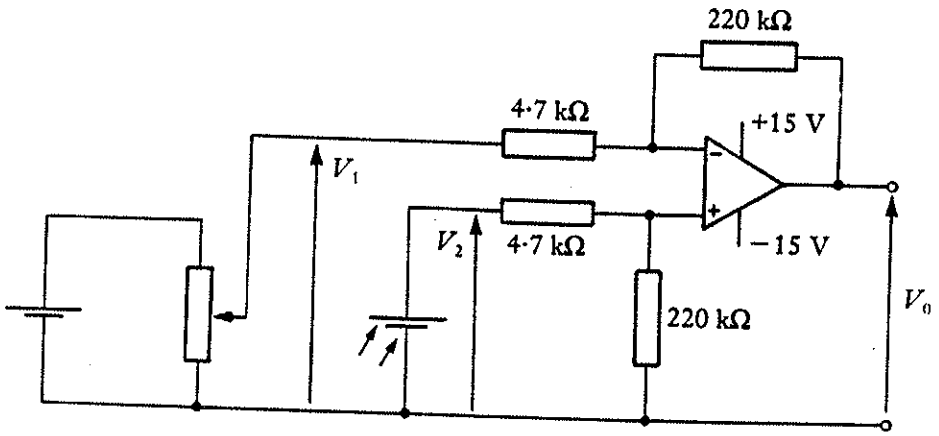


The apparatus is set up near to a window and, with the lamp switched off, there is an output voltage V_0 of $-1{\cdot}75$ V.

(i) Explain why the output voltage V_0 of the operational amplifier is not zero.

(ii) Calculate the solar cell voltage. 3

(*b*) With the solar cell in the same position, the circuit is now altered so that the operational amplifier is working in the differential mode as shown below.



(i) With the lamp still unlit, the potentiometer setting is adjusted until the output voltage is zero.

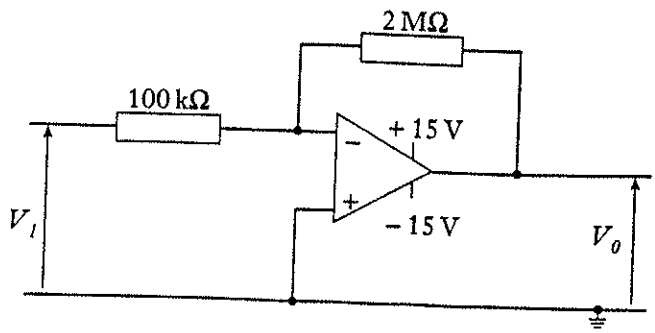
Explain how this circuit enables the output voltage to be set to zero volts.

(ii) With V_1 unchanged, the lamp is switched on and the output voltage V_0 is now 1·50 V.

Calculate the voltage which the solar cell now produces. 4

(7)

2. An op-amp is connected in an amplifier circuit as shown below.

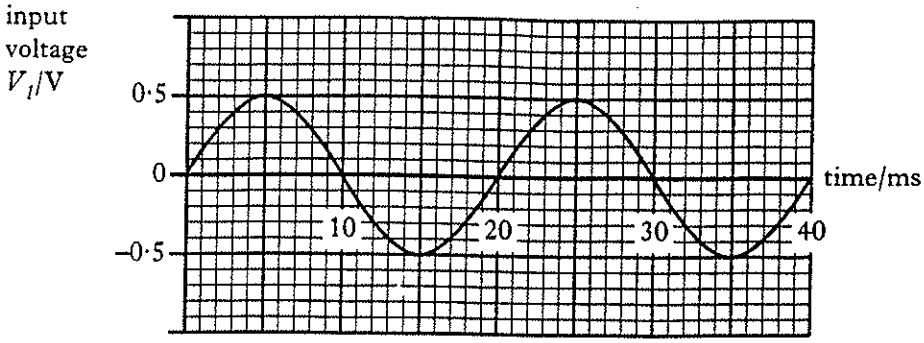


(i) State the mode in which the op-amp is working.

(ii) Calculate the gain of this amplifier circuit.

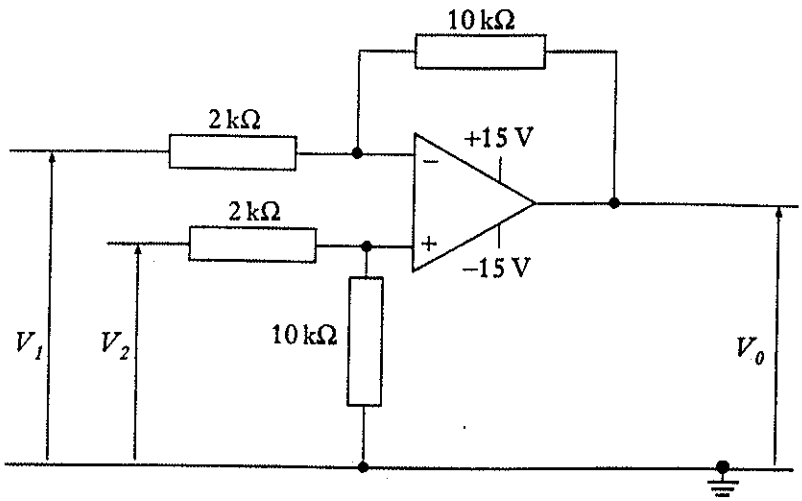
[Turn over

(iii) The following graph shows how the input voltage V_I varies with time.



Sketch a graph to show how the output voltage V_0 varies with time. **(5)**

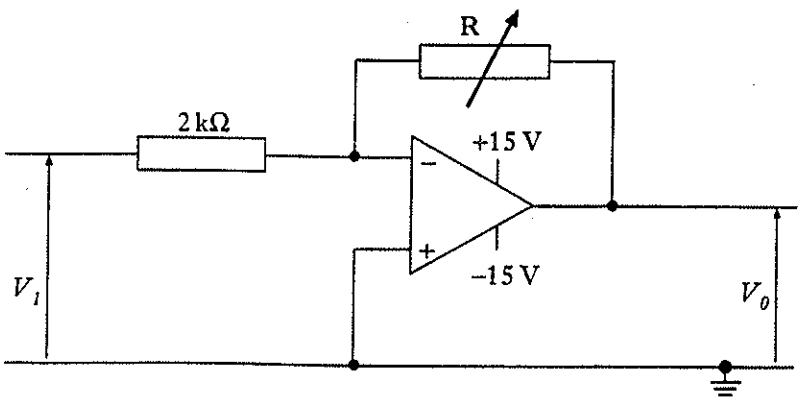
3. (*a*) An operational amplifier is connected in a circuit as shown below.



(i) In what mode is the operational amplifier operating?

(ii) The input voltage V_I is 0·3 V and input voltage V_2 is 0·4 V.
Calculate the output voltage V_0. **3**

(*b*) A second operational amplifier is now connected as shown below.



(i) The input voltage V_I is 0·5 V and the output voltage V_0 is –4·0 V.
Calculate the resistance of R.

(ii) The input voltage V_I is kept at 0·5 V. The resistance of R is gradually increased to 100 kΩ.
Describe what happens to the output voltage V_0. **4**

(7)