TERTIARY ENTRANCE EXAMINATION, 1990

QUESTION/ANSWER BOOKLET

PHYSICS

Please place one of your student identification labels in this box

STUDENT SEA NUMBER—In figures

In words

TIME ALLOWED FOR THIS PAPER

Reading time before commencing: Ten minutes
Working time for paper: Three hours

MATERIAL REQUIRED/RECOMMENDED FOR THIS PAPER

TO BE PROVIDED BY THE SUPERVISOR

This Question/Answer Booklet comprising 41 pages (Section A - 30 questions, Section B - 8 questions)

TO BE PROVIDED BY THE CANDIDATE

Standard Items

Pens, pencils, eraser or correction fluid, ruler

Special Items

Mathematical & Statistical Tables and Chemical Data Booklet, a calculator satisfying the conditions set by the Secondary Education Authority, compass, protractor and set square.

NOTE: Personal copies of Tables/Booklet should not contain any handwritten or typewritten notes, symbols signs, formulae or any other marks (including underlining and highlighting), except the name and address of the candidate, and may be inspected during the examination.

IMPORTANT NOTE TO CANDIDATES

No other items may be taken into the examination room.

It is your responsibility to ensure that you do not have any unauthorised notes or other items of a non-personal nature in the examination room. Please check carefully, and if you have any unauthorised material with you, hand it to the supervisor BEFORE reading any further.

SEE PAGE 3

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SEE PAGE 3

INSTRUCTIONS TO CANDIDATES

This paper consists of TWO (2) sections.

In SECTION A, answer ALL thirty questions, and **write your answers in the spaces provided beneath each question.** This section carries 48% of the total marks for the paper. Each of these questions is of equal value.

In SECTION B, answer ALL questions, and write your answers in the Question/Answer Booklet provided. This section is worth 52% of the total marks for the paper.

In both sections, note that all answers should be given numerically where possible, and that numerical answers should be evaluated and not left in fractional or radical form. Give all answers to three significant figures unless otherwise instructed.

A calculator satisfying the conditions set by the Secondary Education Authority and approved mathematical tables may be used to evaluate numerical answers.

Despite an incorrect final result, credit may be obtained for method and working, provided these are clearly and legibly set out.

At the commencement of this examination, attach your STUDENT IDENTIFICATION label to the front cover of this Question/Answer Booklet. Write your student SEA number in the spaces provided in the Question/ Answer Booklet.

REFER TO PAGE 41 FOR PHYSICAL CONSTANTS

NOTE: Page 41 is perforated and may be removed for easier use during the examination.

SEE PAGE 4

SECTION A

MARKS ALLOTTED : 48

Attempt all thirty (30) questions in this section. All questions are worth equal marks. **Answers are to be written in the spaces provided for each question below or next to the questions.**

Evaluate answers numerically where possible. Credit will be given for working, if shown. Numerical constants are listed on page 41.

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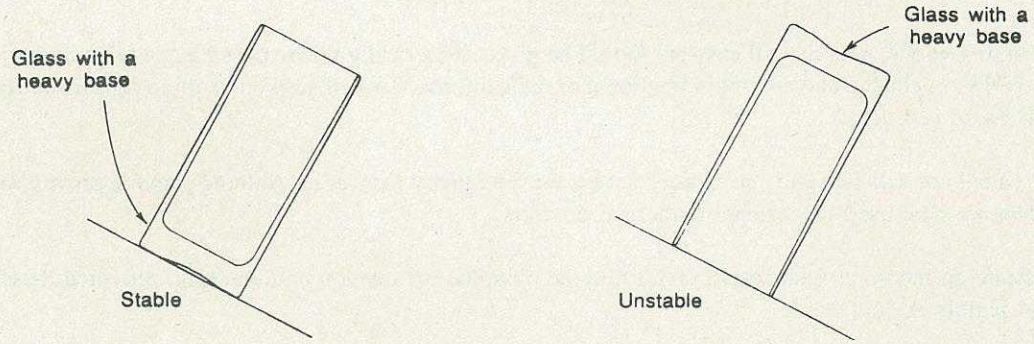
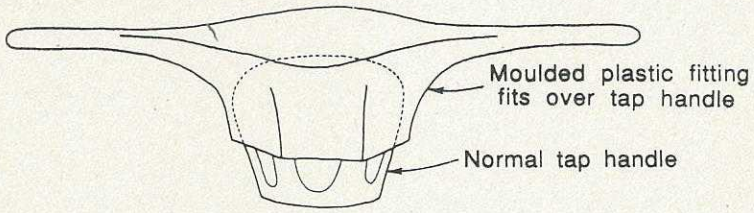
1. A drinking glass with a heavy base and straight sides is put on a sloping surface. When placed base down it is stable, but when placed base up it topples over. With reference to the diagrams explain why this happens.



2. People with severe arthritis (a disease of the joints) in their hands often have difficulty turning normal taps on and off. A tap-making company has recognised this and developed a device which fits over a tap and has two arms as shown in the diagram below.

Upon what principle does the device depend for its operation? Illustrate your answer by reference to the diagram below.



SEE PAGE 5

3. A child of mass 38·0 kg sits on the seat of a swing of mass 2·00 kg. The distance from the top of the swing to the centre of mass of the child and the swing combined is 2·80 m. Calculate the tension in each of the two supporting ropes when the child is at the bottom of the arc and the swing is moving at 2·40 m s^{-1}.

4. Determine the value of the acceleration due to gravity at a position $2{\cdot}50 \times 10^2$ km above the surface of the Earth.

5. Reconcile your answer to question 4 above with the fact that an astronaut in orbit around the Earth at this height (i.e. $2{\cdot}50 \times 10^2$ km above the Earth's surface) experiences weightlessness.

SEE PAGE 6

6. When a person in a room coughs, one or two of the lower notes of a piano in the same room are often heard to sound. Name the physical phenomenon of which this is an example and explain why only a few notes sound.

7. While tuning a violin, a player hears 4 beats per second from a string when it is played together with a tuning fork marked "D-297 Hz".

On tightening the string slightly the player hears 6 beats per second. From this information

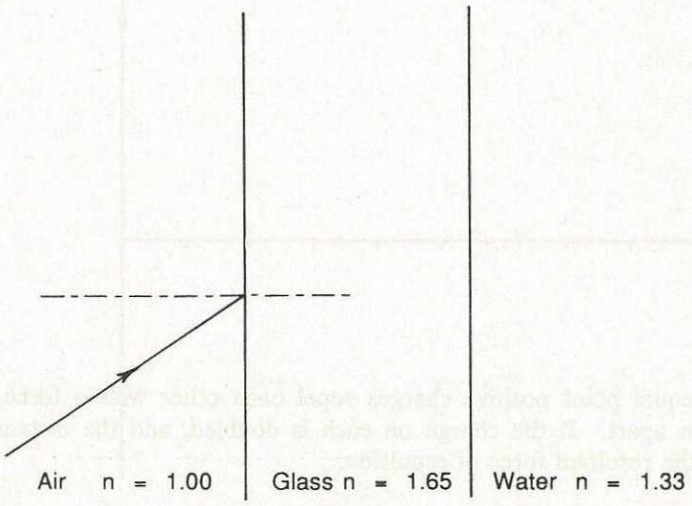
(a) calculate the original frequency of the untuned violin string and

(b) describe what further adjustment will be needed in order to tune the violin string to the required 297 Hz.

SEE PAGE 7

8. A beam of red light of wavelength approximately 560 nm passes obliquely from air, through glass, into water.

(a) Sketch the path of the ray as it passes into the glass and then into the water. (Do not calculate angles.)



(b) State what happens to the velocity, frequency and wavelength by using the words **increases, decreases** or **remains the same** as the ray passes from the air into the glass.

As the light passes from air to glass the

- velocity _____
- frequency _____
- wavelength _____

9. When a simple convex lens is used to focus an image of a distant white light source onto a screen, it is possible to produce an image with a red border and an image with a blue border.

(a) Name the phenomenon that causes this. _____

(b) Use notes and a diagram or diagrams to explain how this comes about.

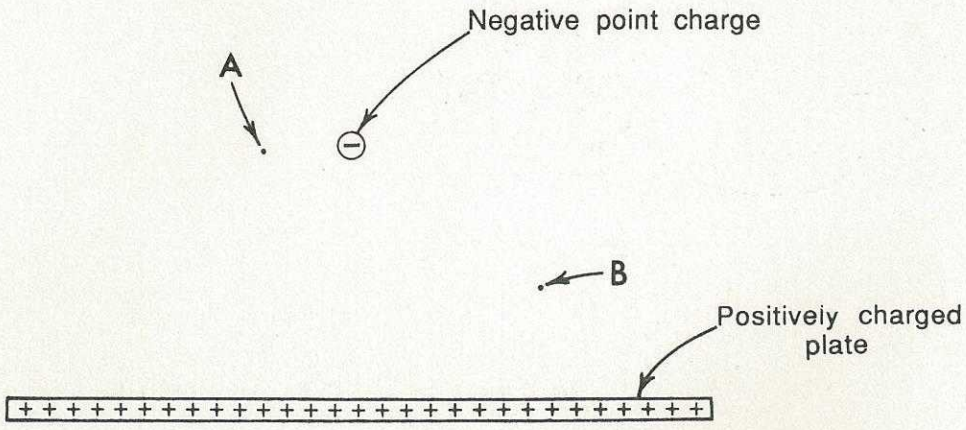
SEE PAGE 8

10. Describe the difference between the spectrum of the yellow light emitted from sodium vapour lamps, such as those located near crosswalks, and the spectrum of an ordinary incandescent tungsten filament globe that has been painted yellow to keep mosquitos away from an outdoor barbeque area. Sketch a diagram to illustrate your answer.

11. Two unequal point positive charges repel each other with a force of 0·150 N when they are 30·0 mm apart. If the charge on each is doubled, and the distance between them is trebled, what is the resultant force of repulsion.

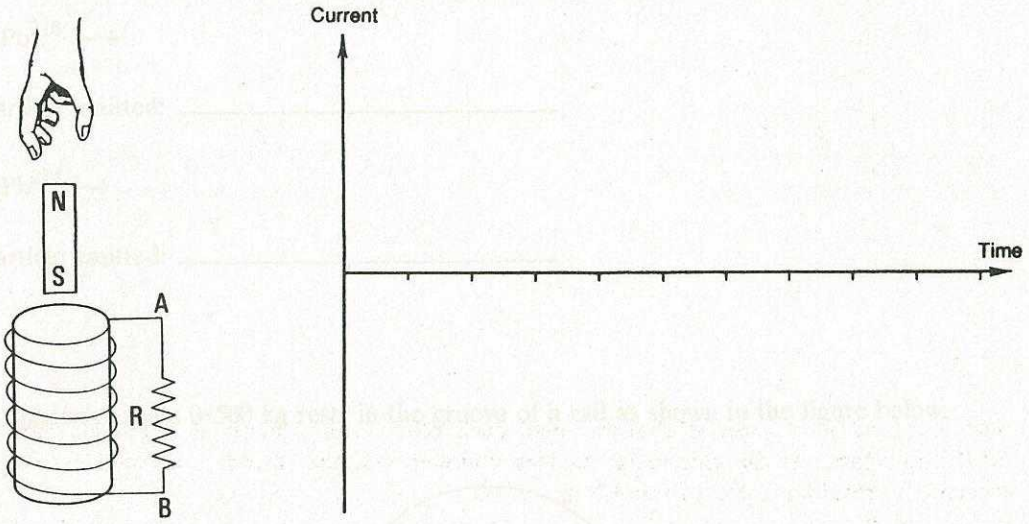
12. (a) Draw the electric field between the positively charged plate and the negative point charge shown in the diagram below.

(b) Draw vectors on the diagram below to compare the force on a small negatively charged object placed at position A with the force on a small negatively charged object placed at position B. Show the direction and the relative magnitude of the forces in each case.



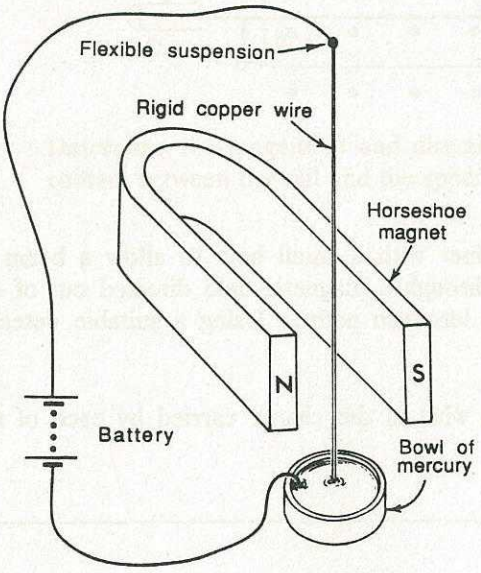
SEE PAGE 9

13. A bar magnet is dropped through a coil of wire which is wound on a hollow plastic cylinder as shown in the diagram. Sketch a graph showing how the current through the resistor R varies with time as the magnet passes through the coil. Take current flow in the direction A to B as positive.



14. A rigid piece of copper wire is suspended between the poles of a horseshoe magnet as shown in the diagram. The lower end of the wire is in a bowl of mercury and is free to move. A current is passed down the wire with the mercury in the bowl acting as a moving contact.

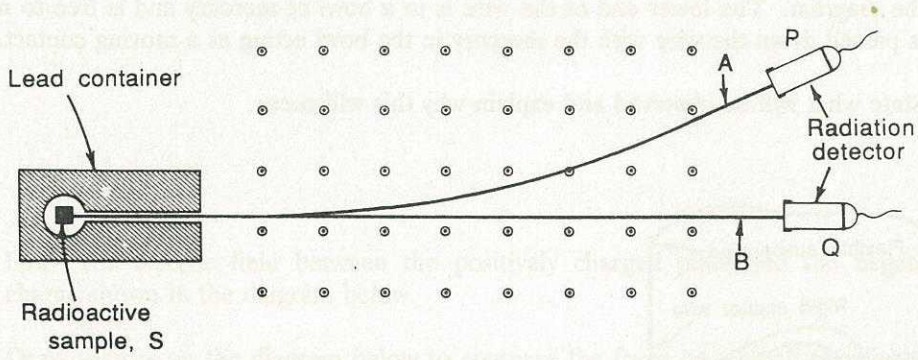
State what will be observed and explain why this will occur.



SEE PAGE 10

15. The velocity of a photoelectron ejected from the surface of a metal by a photon is $1{\cdot}75 \times 10^6$ m s^{-1}. If the electron was initially at rest in the metal and 60·0% of the energy of the photon appears as the kinetic energy of the electron, determine the frequency of the photon.

16. The apparatus in the diagram could be used to identify the nature of the charge which is carried by two natural nuclear radiations.



A radioactive sample S is placed in a lead container with a small hole to allow a beam of radiation to escape as shown. The beam passes through a magnetic field directed out of the page, which causes the beam of radiation to split into two paths. Using a suitable detector radiation is observed at positions P and Q.

(a) From the paths illustrated in the diagram what is the charge carried by each of the radiations A and B?

A: _____

B: _____

(b) What type of particles could A and B be?

A: _____

B: _____

SEE PAGE 11

17. In a radioactive series the element $_{84}Po^{218}$ decays to $_{82}Pb^{214}$ and this in turn decays to $_{83}Bi^{214}$. Write the nuclear reaction associated with each decay and in each case name the particles emitted.

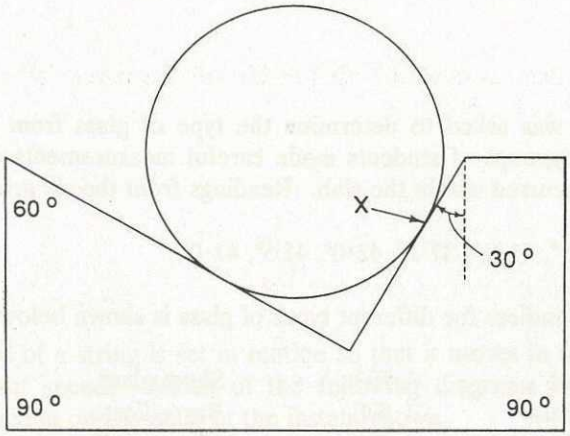
$_{84}Po^{218} \longrightarrow$

particle emitted: _____

$_{82}Pb^{214} \longrightarrow$

particle emitted: _____

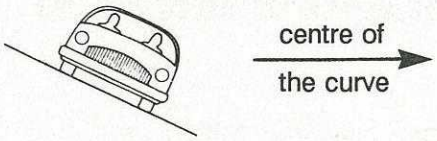
18. A sphere of mass 0·500 kg rests in the groove of a rail as shown in the figure below.



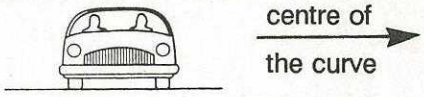
Determine the magnitude and direction of the force exerted on the sphere at **X**, the point of contact between the rail and the sphere.

SEE PAGE 12

19. Use notes and the diagrams below to explain why curves on open highways are built with a bank (or slope) as shown below.



car moving around a corner on a banked road



car moving around a corner on a flat road

20. A class of students was asked to determine the type of glass from which a slab of glass was made. Six different groups of students made careful measurements of the angle at which total internal reflection occurred within the slab. Readings from the six groups were as follows:

41·5°, 41·0°, 37·5°, 42·0°, 41·5°, 41·0°

A table of refractive indices for different types of glass is shown below (λ = 589 nm).

Lead Crystal	1·693	Sheet glass	1·510
Light flint glass	1·578	Borosilicate	1·474
Alumino-silicate glass	1·532	Vitreous silica glass	1·458

From these data determine the type or types of glass from which this sample is most probably made. Justify your answer.

SEE PAGE 13

For each of the next ten questions, choose which one of the alternatives **best** answers the question and indicate your choice by writing the appropriate letter in the box provided.

21. Object A has mass 2 kg, object B has mass 8 kg and both are initially at rest. Both bodies are acted upon by equal forces for equal times.

The final value of the ratio $\frac{\text{momentum A}}{\text{momentum B}}$ is

A. 1 : 16

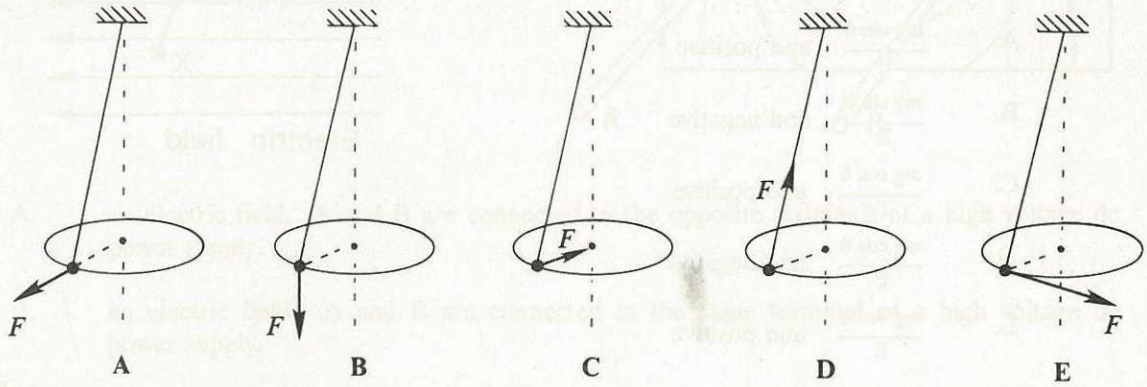
B. 1 : 4

C. 1 : 2

D. 1 : 1

E. 2 : 1

22. A mass on the end of a string is set in motion so that it moves in a circular path in a horizontal plane at a constant speed. Which of the following diagrams indicates the direction of the resultant force F acting on the mass at the instant shown.



SEE PAGE 14

23. The acceleration due to gravity at the surface of the Earth is approximately six times that at the surface of the Moon. Assume the densities of the Earth and the Moon are the same.

The ratio $\frac{\text{radius of Earth}}{\text{radius of Moon}}$ is

A. 216 : 1

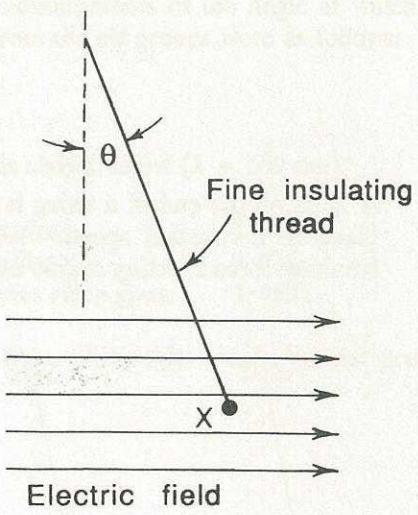
B. 36 : 1

C. 6 : 1

D. $\sqrt{6}$: 1

E. $\sqrt[3]{6}$: 1

24. A small charged sphere **X** of mass m kg is attached to a point by a fine insulating thread. When an electric field of strength E V m^{-1} is applied as illustrated, the sphere is deflected to the right and comes to rest at an angle of θ to the vertical.



The magnitude of the charge on the sphere and the sign of the charge is

A. $\frac{mg \sin \theta}{E}$ and positive

B. $\frac{mg \sin \theta}{E}$ and negative

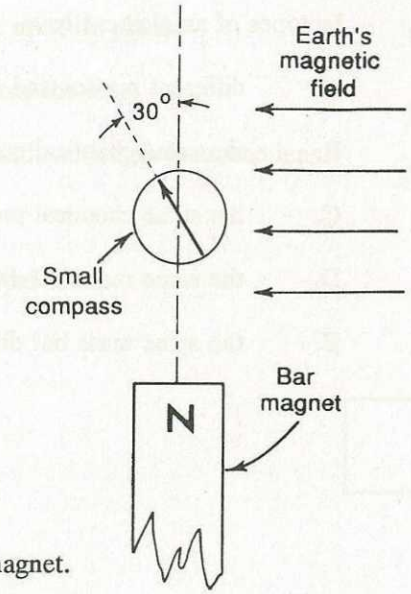
C. $\frac{mg \cos \theta}{E}$ and positive

D. $\frac{mg \cos \theta}{E}$ and negative

E. $\frac{mg \tan \theta}{E}$ and positive

SEE PAGE 15

25. The figure at the right shows the direction a small compass needle points under the combined influence of the Earth's magnetic field and a bar magnet. The direction taken by the compass shows that the magnetic field strength of the Earth's magnetic field at that position



A. is greater than that provided by the magnet.

B. is less than that provided by the magnet.

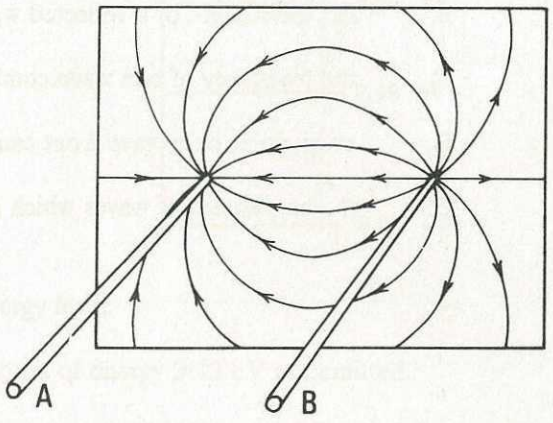
C. is equal to that provided by the magnet.

D. may be greater or less than that provided by the magnet.

E. is one third the strength of that provided by the magnet.

26. Two copper wires A and B produce a field in the plane of the paper as shown in the figure at the right.

This field is



A. an electric field. A and B are connected to the opposite terminals of a high voltage dc power supply.

B. an electric field. A and B are connected to the same terminal of a high voltage dc power supply.

C. a magnetic field. A and B are conductors carrying current in opposite directions.

D. a magnetic field. A and B are conductors carrying current in the same direction.

E. a combination of an electric field and a magnetic field.

SEE PAGE 16

27. Isotopes of an element have

A. different masses and different atomic numbers.

B. the same chemical properties but different masses.

C. the same chemical properties but different atomic numbers.

D. the same mass but different atomic numbers.

E. the same mass but different number of electrons.

28. The superposition principle of waves states that

A. the diffraction pattern depends on the ratio of the wavelength to the slit width.

B. the wavelength of a reflected wave equals the wavelength of the incident wave.

C. the frequency of one wave combines with that of another to produce beats.

D. every point on a wave front can be considered to behave as a point source of waves.

E. the amplitudes of waves which coincide at a point may be added.

SEE PAGE 17

29. In using a converging lens as a magnifying glass, the object must be placed

A. at a distance greater than twice the focal length from the lens.

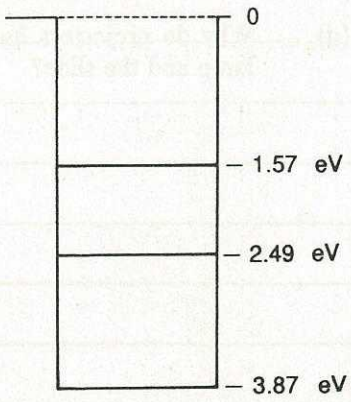
B. at a distance between the focal length and twice the focal length from the lens.

C. at the principal focus of the lens.

D. at a point slightly closer to the lens than the principal focus.

E. as close to the lens as possible.

30. The energy level diagram for electrons in atomic caesium is shown at the right.



Which of the following could occur if a photon of energy 7·00 eV is incident on a caesium atom in its ground state?

A. The electron will jump to the highest energy level.

B. An electron of energy 3·87 eV and a photon of energy 3·13 eV are emitted.

C. The atom would be ionised, and an electron would be ejected with a kinetic energy of 3·13 eV.

D. Two photons, of energy 2·30 eV and 4·70 eV respectively, are emitted.

E. Three photons, of energy, 1·38 eV, 2·30 eV and 3·87 eV respectively, are emitted.

SEE PAGE 18

SECTION B

MARKS ALLOTTED : 52

Attempt **ALL** questions in this section. Credit will be given for method and reasoning if these are clearly shown. Answers should be evaluated numerically. Numerical constants which may be required are listed on page 41 and/or within the question itself.

[7 marks]

1. A slide measuring 20·0 mm by 20·0 mm is projected onto a screen which is 2·00 m away from the slide. If the screen measures 1·50 m by 1·50 m and the whole screen is to be filled by the image of the slide, determine

   (a) the type of projection lens to be used.

   (b) the focal length of the lens needed to achieve this.

   (c) the distance the lens is to be placed from the slide.

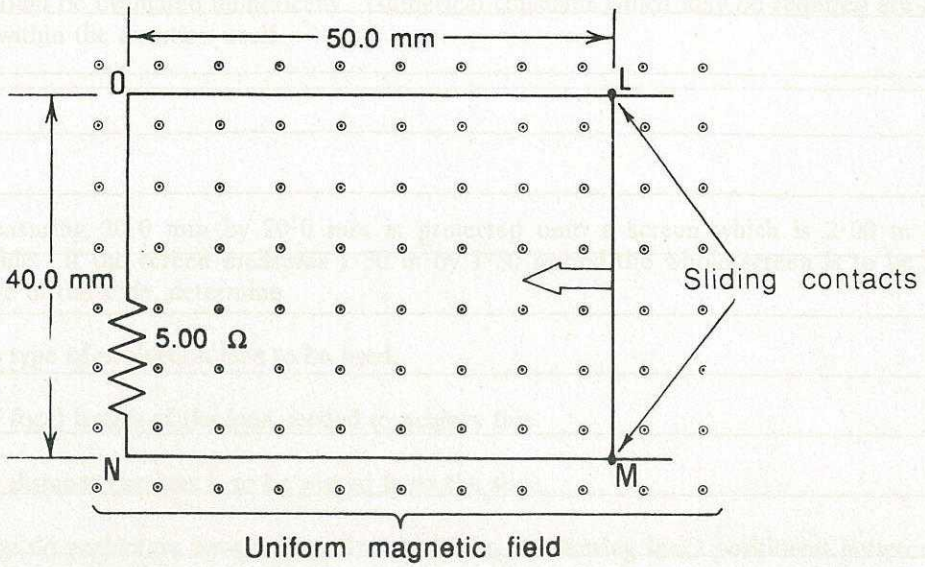
   (d) Why do projectors have a large lens (called a condensing lens) positioned between the lamp and the slide?

SEE PAGE 19

SEE PAGE 20

[6 marks]

2. A U-shaped wire has a second movable wire LM connected across its parallel arms with L and M forming sliding contacts as shown in the diagram below. This arrangement is in a uniform magnetic field perpendicular to, and directed out of, the page.



(a) If the magnetic field strength is 50·0 Wb m^{-2}, what is the induced emf (in volts) when wire LM is in the position shown and moving at 0·0250 m s^{-1} to the left?

(b) In which direction does current flow (LMNO or LONM) around this loop?

(c) At what rate must work be done to keep the wire LM moving at 0·0250 m s^{-1} as shown?

(d) Will the rate of work need to be greater or smaller if the 5·00 Ω resistor is replaced with a resistor of lower resistance?

SEE PAGE 21

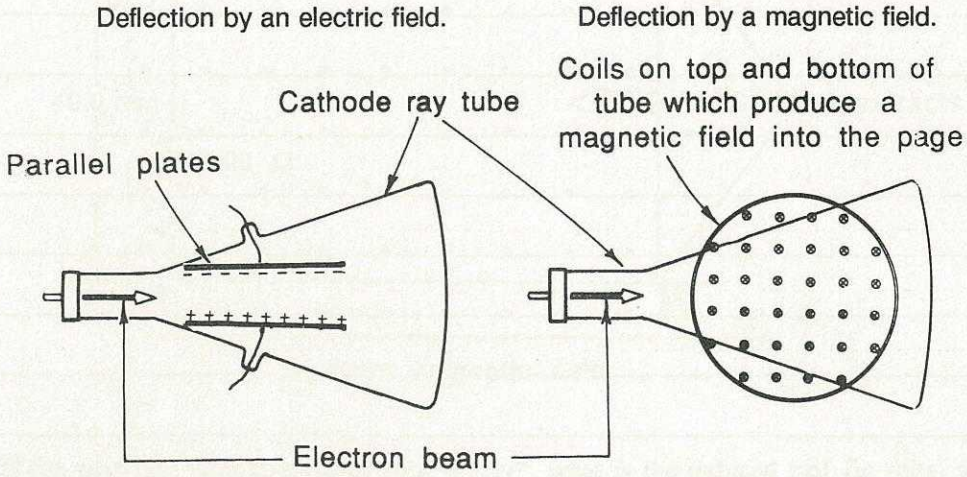
SEE PAGE 22

[6 marks]

3. An electron beam in a cathode ray tube can be deflected by either an electric field or a magnetic field.

(a) Use the diagrams below and write notes to compare

- the direction of deflection and electron path produced by each field,
- the magnitude of the force produced, and
- the effect of the deflecting force on the speed of the electrons.



(b) Show on a diagram how an electric field and a magnetic field could be arranged so that together they produce no resultant force on an electron passing through them.

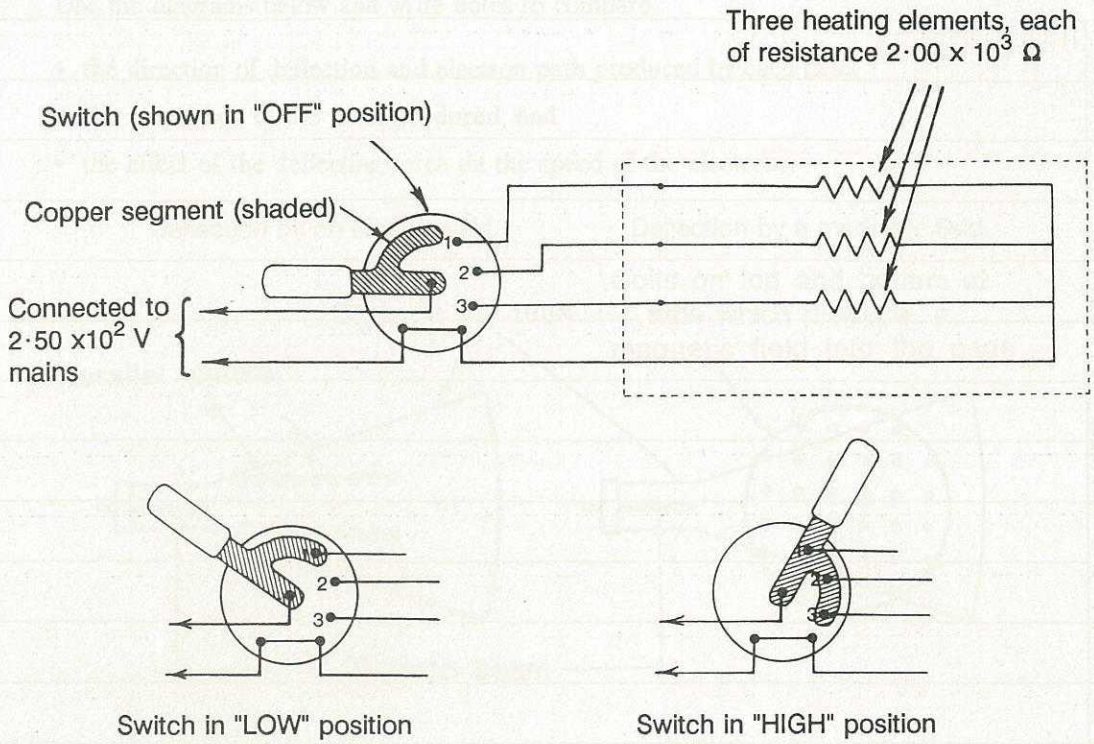
SEE PAGE 23

(c) Explain why the situation in part (b) occurs only for electrons of one particular velocity. What would this velocity be for an electric field of $1{\cdot}50 \times 10^4$ V m^{-1} and a magnetic field of 0·300 T?

SEE PAGE 24

[6 marks]

4. An electric blanket contains three identical heater elements, each of resistance $2{\cdot}00 \times 10^3\ \Omega$. The blanket is connected to the $2{\cdot}50 \times 10^2$ V mains by a switch which has four settings.



Switch in "LOW" position

Switch in "HIGH" position

The switch works by connecting

- terminal 1 only for the low setting.
- terminals 1 and 2 together for the medium setting.
- terminals 1, 2 and 3 together for the high setting.

Calculate

(a) the rate of production of heat energy in the blanket for

(i) the low setting and

(ii) the high setting.

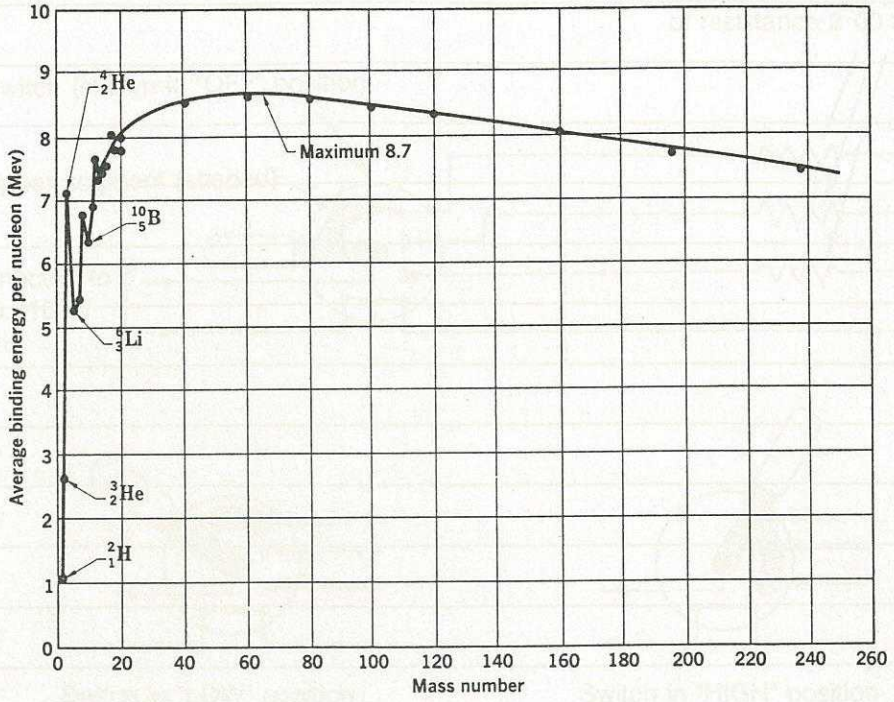
(b) The cost of leaving the blanket on high for a period of 12·0 hours if electricity costs are 10·5 c per unit (1 unit = 1 kW hour).

SEE PAGE 25

SEE PAGE 26

[7 marks]

5. The following graph shows the relationship between the average binding energy per nucleon and mass number of various nuclides.



(a) Define and explain the meaning of the term nuclear mass defect.

(b) Calculate the total nuclear binding energy in MeV associated with the nucleus of a $^{4}_{2}$He nucleus.

m_p = 1·007 277 u
m_n = 1·008 665 u
m_{He} = 4·001 509 u
1u = 931 MeV

(c) Is this value consistent with the value for $^{4}_{2}$He provided on the graph above?

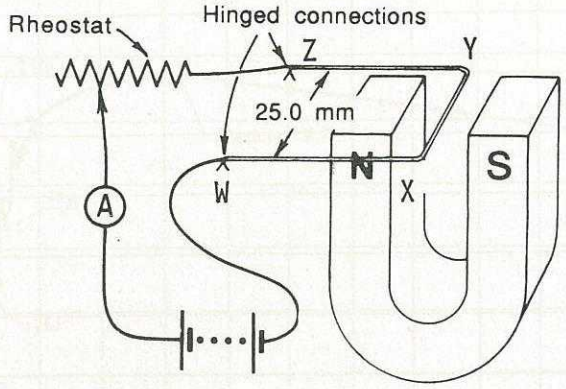
(d) With reference to the graph above explain the difference between fission and fusion.

SEE PAGE 27

SEE PAGE 28

[7 marks]

6. In order to determine the relationship between current flowing in a wire and the force on the wire when the wire is perpendicular to a magnetic field, an experiment was set up as shown below.



The wire loop WXYZ is hinged so the segment XY can move vertically between the poles of the horseshoe magnet. Current through the loop is directed so that there is an upwards force on XY. The current is adjusted until the loop is horizontal. The length of XY in the field is 25·0 mm.

Small masses of 50·0 mg each are then placed, one at a time, on wire XY. After each mass is added, the current is adjusted until the loop is again horizontal. The mass and current are recorded for each case.

The following raw data was obtained.

Masses added to XY (mg)	Force on XY due to mass added to XY (N)	Current flowing in XY (A)
no masses	0.00	2·2
50·0		2·8
100·0		3·3
150·0		3·5
200·0		4·5
250·0		5·0
300·0		5·7
350·0		6·2

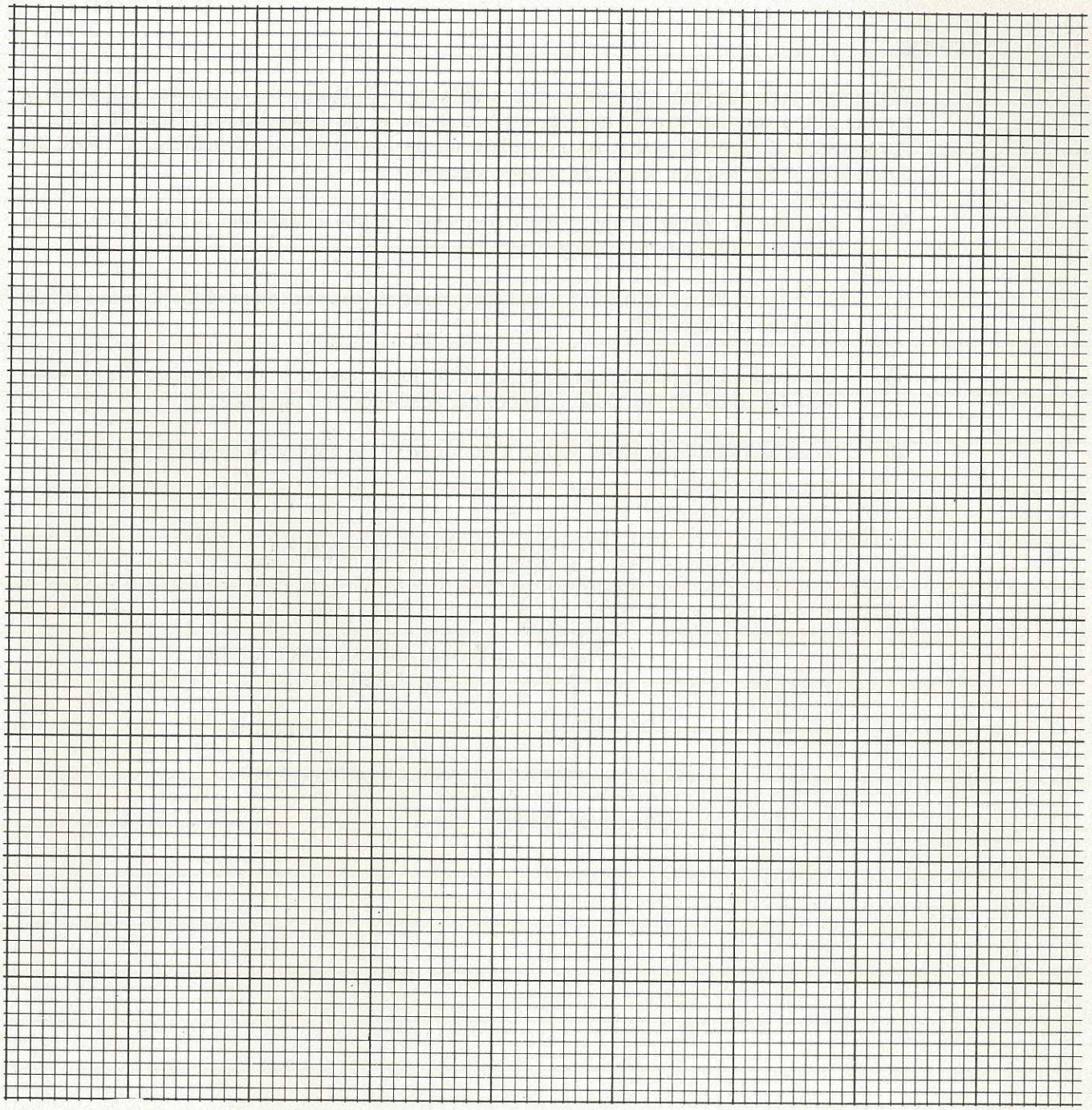
(a) Complete the middle column of the table.

(b) Using the data in the table plot a graph of force versus current flowing through the wire.

(c) Explain why this graph does not pass through the origin on the graph.

(d) Determine the slope of the graph and use this value to determine the magnetic field intensity of the magnet.

SEE PAGE 29



SEE PAGE 30

[7 marks]

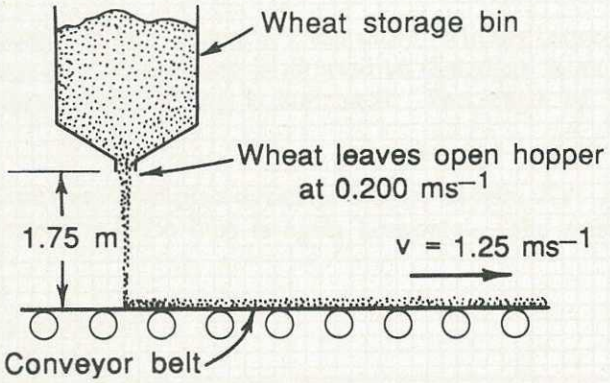
7. Wheat falls vertically from an open hopper a distance of 1·75 m onto a conveyor belt which is moving with a constant velocity of 1·25 m s^{-1} as shown in the figure below. If the flow rate of the wheat is 10·0 kg s^{-1} and it is assumed it has an initial velocity of 0·200 m s^{-1} vertically downwards at the instant it leaves the hopper, calculate

(a) the rate of change in the vertical component of the momentum of the wheat at the instant it falls onto the conveyor belt.

(b) the rate of change in the horizontal component of the momentum of the wheat as it falls onto the conveyor belt.

(c) the resultant magnitude and direction of the force exerted by the wheat on the conveyor belt due to the impact alone. (Ignore the weight force of the wheat.)

(d) State how this force would change if the speed of the conveyor belt were to increase.

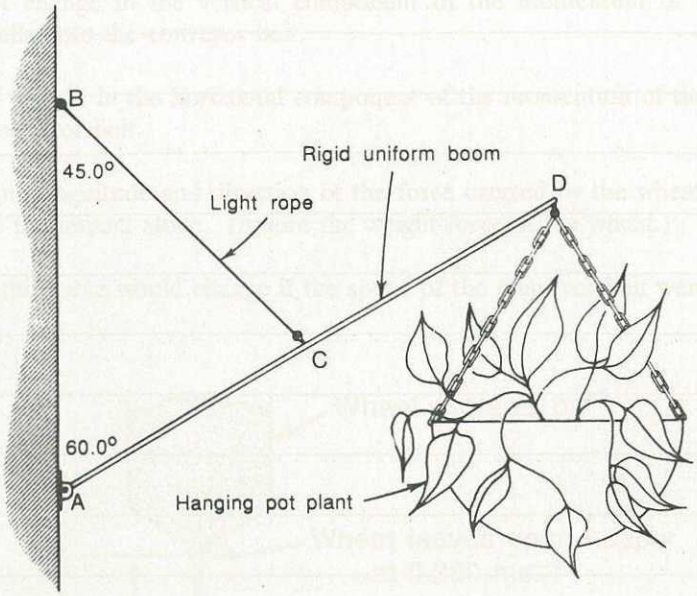


SEE PAGE 31

SEE PAGE 32

[6 marks]

8. A support for a hanging pot plant consists of a 0·500 m long uniform rigid boom AD of mass 0·750 kg pivoted at the lower end and supported by a light rope to the wall as shown in the figure below. The angles are as shown.



The angles ABC and BAC are 45·0° and 60·0° respectively and the support cable BC is connected to the mid-point of AD at C. The mass of the pot plant and basket is 2·20 kg.

(a) Calculate the tension in the rope.

(b) Calculate the magnitude and direction of the force exerted by the wall on the boom at the point A.

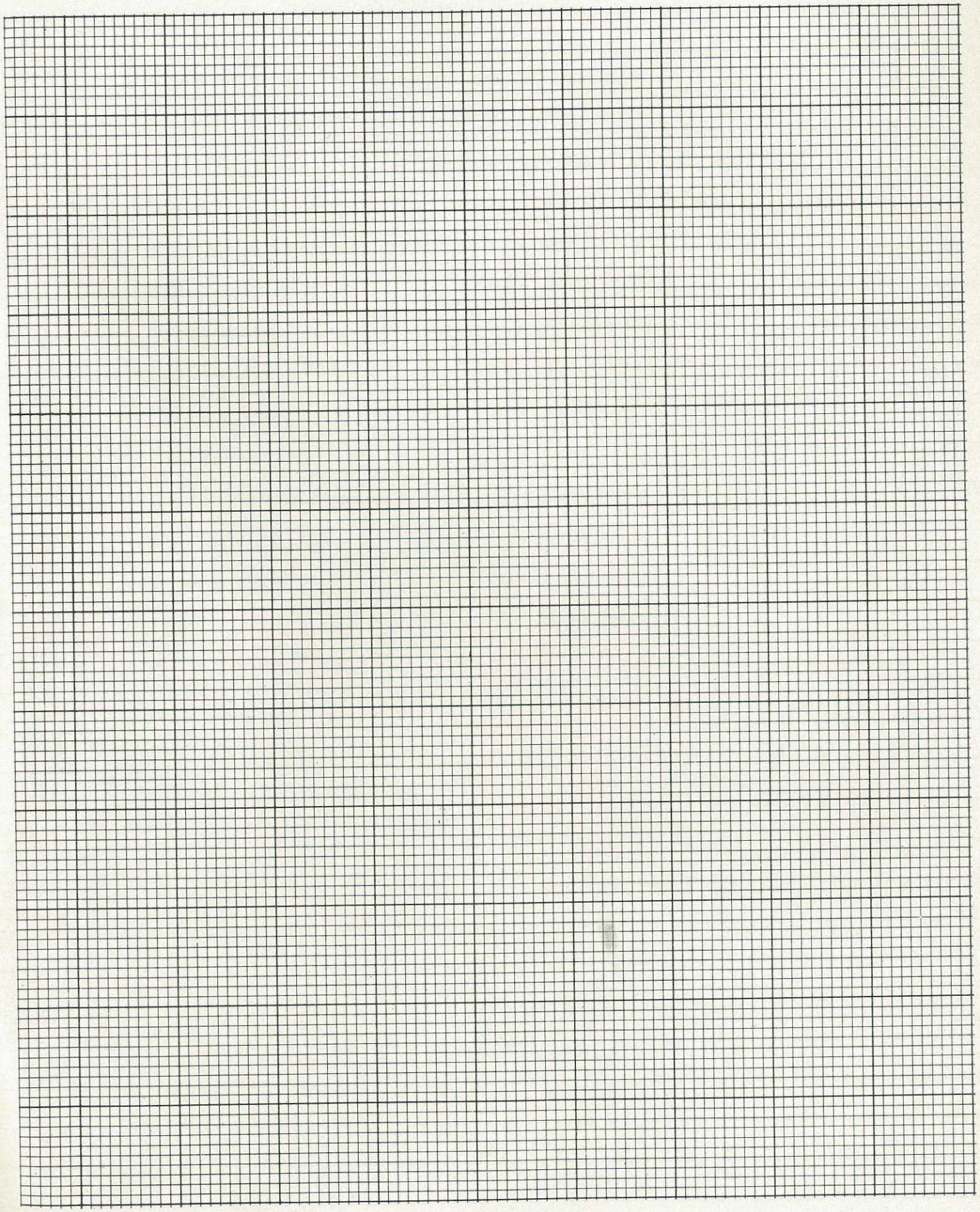
(c) Describe how the magnitude and direction of the force on A would alter if angle BAC were to be increased.

END OF QUESTIONS

SEE PAGE 33

SEE PAGE 34

SEE PAGE 39



SEE PAGE 40

END OF PAPER

PHYSICAL CONSTANTS

The following physical constants should be used where necessary:

Acceleration due to gravity	$g = 9{\cdot}80 \text{ m s}^{-2}$
Speed of light in air	$c = 3{\cdot}00 \times 10^{8} \text{ m s}^{-1}$
Permittivity of free space	$\varepsilon_o = 8{\cdot}85 \times 10^{-12} \text{ C}^2 \text{ N}^{-1} \text{ m}^{-2}$
Permeability of free space	$\mu_o = 4\pi \times 10^{-7} \text{ N A}^{-2}$
Electron charge	$e = -1{\cdot}602 \times 10^{-19} \text{ C}$
Mass of electron	$m_e = 9{\cdot}11 \times 10^{-31} \text{ kg}$
Planck's constant	$h = 6{\cdot}63 \times 10^{-34} \text{ J s}$
1 atomic mass unit	$u = 1{\cdot}661 \times 10^{-27} \text{ kg}$
Refractive index of air	$n_a = 1{\cdot}00$
Universal gravitational constant	$G = 6{\cdot}67 \times 10^{-11} \text{ N m}^2 \text{ kg}^{-2}$
Mean radius of the Earth	$r_E = 6{\cdot}37 \times 10^{6} \text{ m}$
Mass of the Earth	$M_E = 5{\cdot}98 \times 10^{24} \text{ kg}$
1 tonne	$= 1{\cdot}00 \times 10^{3} \text{ kg}$