BOARD OF STUDIES
NEW SOUTH WALES

STUDENT NUMBER

CENTRE NUMBER

HIGHER SCHOOL CERTIFICATE EXAMINATION

1998

ENGINEERING SCIENCE

2/3 UNIT (COMMON)

SECTION I

(48 Marks)

Total time allowed for Sections I and II—Three hours
(Plus 5 minutes reading time)

DIRECTIONS TO CANDIDATES

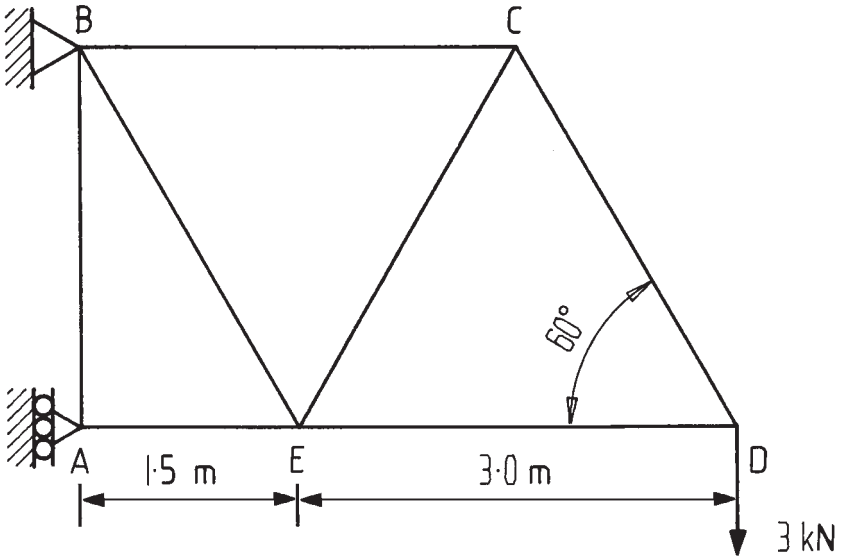
- Write your Student Number and Centre Number at the top right-hand corner of this page.
- Allow approximately 90 minutes for this Section.
- Attempt ALL questions.
- Answer the questions in the spaces provided in this paper. Set out your working clearly and neatly. Emphasis will be placed on that working when marks are allocated.
- All questions are of equal value.
- Diagrams throughout this paper are to scale, unless otherwise stated.
- Drawing instruments and Board-approved calculators may be used.
- A Formulae sheet is provided on page 33.
- The Formulae sheet and Rough Work sheet (page 34) will not be collected.

MARKER'S USE ONLY

Question	Max. Marks	Marks Awarded	Marks Checked
1	8		
2	8		
3	8		
4	8		
5	8		
6	8		
TOTAL	Max. 48		

QUESTION 1 **Marks**

Details of a timber truss are given below on the diagram. The truss has a mass of 120 kg acting through joint E. A vertical force of 3 kN acts through a steel cable at joint D.



(a) Determine the reactions at the supports A and B. **3**

Magnitude of reaction at A ..... kN. Direction .....

Magnitude of reaction at B ..... kN. Direction .....

QUESTION 1. (Continued) **Marks**

(b) Determine the magnitude and nature (tension or compression) of the force in member BC. **2**

Force in BC ..... kN

Nature of force in BC .....

(c) The steel cable at joint D has a tensile yield stress of 250 MPa. Using a factor of safety of 1·5, determine the minimum diameter of steel cable that should be used to withstand the 3 kN force. **3**

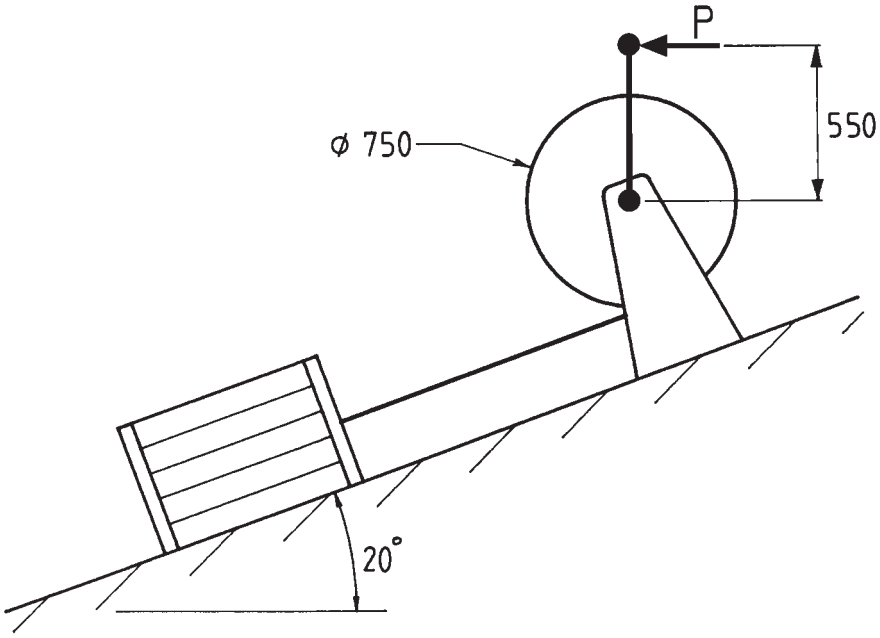
Minimum diameter ..... mm

QUESTION 2 **Marks**

Details of a winch mechanism used to raise and lower crates on an inclined plane are given on the diagram below. The mass of each crate is 300 kg.

The coefficient of static friction between the crate and the plane is 0·2.

The coefficient of dynamic friction between the crate and the plane is 0·14.



(a) (i) Determine the minimum tension in the rope required to prevent the crate sliding down the plane. **3**

Tension in rope ..... N

(ii) Determine the tension in the rope if the crate is moving up the plane with a constant velocity.

Tension in rope ..... kN

QUESTION 2. (Continued) **Marks**

(b) For a different set of conditions, a tension of 1·2 kN in the rope moves a crate up the plane with a constant velocity. **3**

(i) Determine the force, P, that needs to be applied at the handle of the winch to cause this motion.

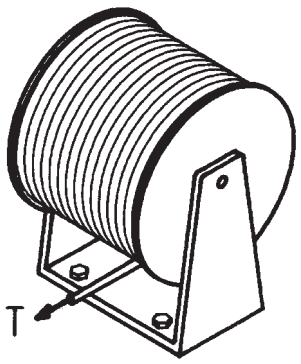
Force P ..... N

(ii) If the winch has an efficiency of 85%, determine the work required to turn the winch five full revolutions.

Work ..... kJ

(c) The winch mechanism has a mass of 160 kg and is held to the inclined plane by 4 identical bolts. The maximum shearing force on the bolts, caused by the tension T in the rope, was found to be 4·65 kN. **2**

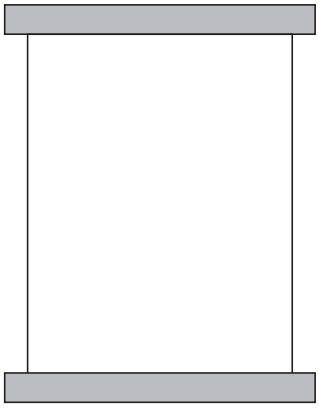
Determine the minimum diameter of the bolts used, if each has a maximum shear stress of 150 MPa.



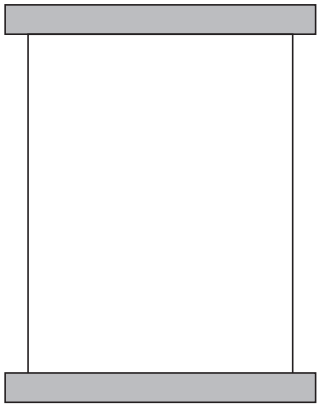
Minimum diameter ..... mm

QUESTION 3 **Marks**

(a) (i) Two concrete specimens are tested to destruction in a compression test. Using the diagrams below, draw the TWO different types of failure that could occur. **3**



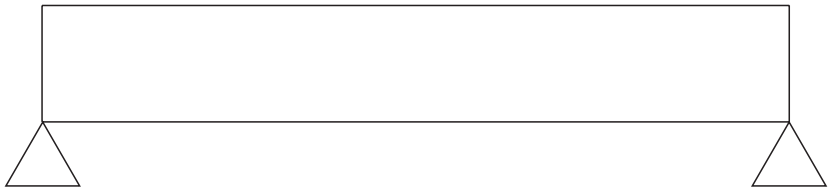
SPECIMEN 1



SPECIMEN 2

(ii) A concrete beam is supported as shown below.

On the diagram, indicate the approximate position of a reinforcing rod to minimise tensile cracking.



(iii) There are two methods of pre-stressing the beam. Name and describe ONE of these methods.

Name .....

Description .....

.....

.....

.....

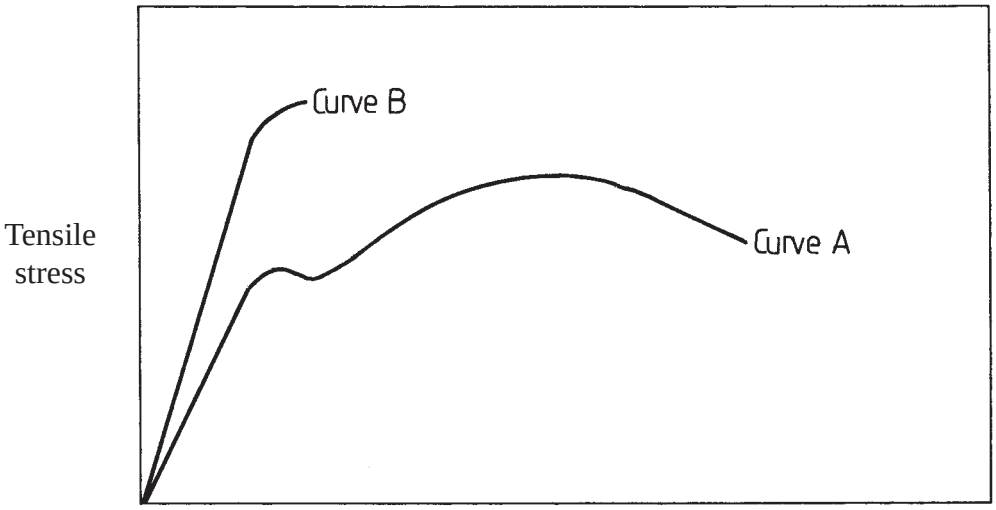
(b) Powder metallurgy is often used in the manufacture of bronze bearings. Give TWO advantages that this process has over machining the bearing from solid bar stock. **1**

Advantage 1 .....

Advantage 2 .....

QUESTION 3. (Continued) **Marks**

(c) The diagram below represents the tensile stress–strain curves for mild steel (curve A) and a hardened and tempered steel (curve B). **2**



In the table below, indicate the steel with the higher value for each of the mechanical properties given. Give a reason for each answer by referring to the curves given above. A sample answer has been provided.

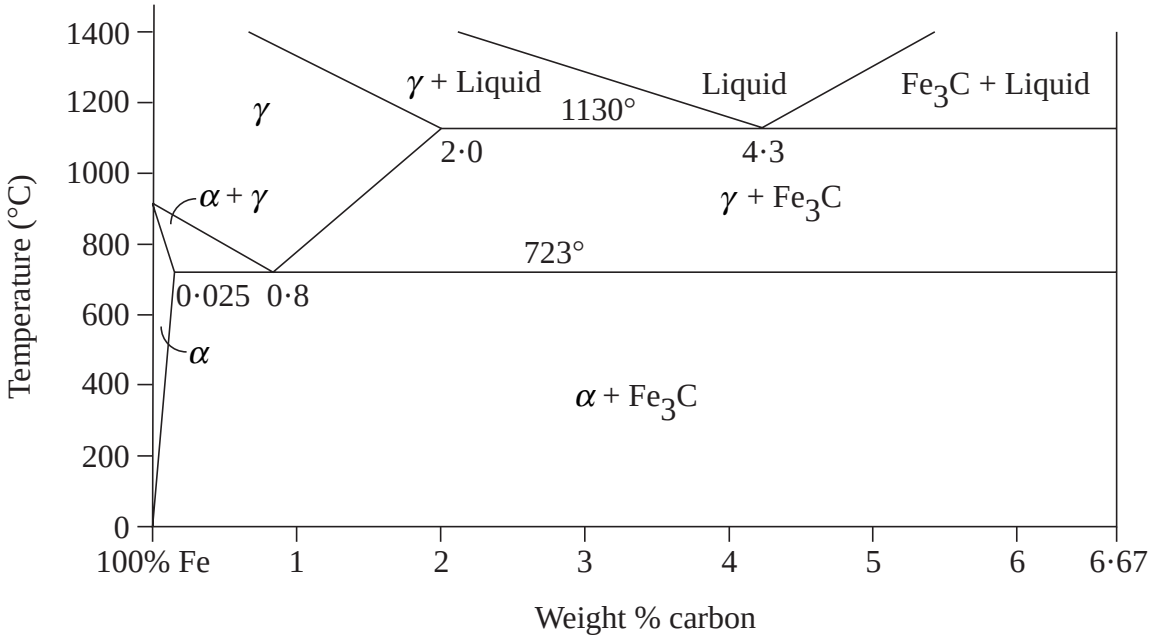
Mechanical Property	*Steel* (A *or* B)	*Reason*
Tensile strength	B	Higher UTS shown on diagram
Ductility		
Toughness		

(d) Name a suitable mass production method for EACH of the following products. **2**

- Flexible, narrow-necked PET bottle .....
- Thin polyethylene wrapping film .....
- Stoneware toilet bowls .....
- Glass fibre .....

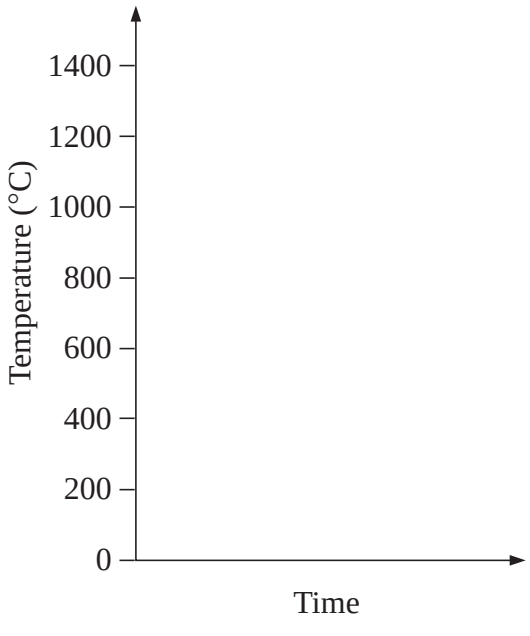
QUESTION 4 **Marks**

A portion of the iron–carbon equilibrium diagram is given below.

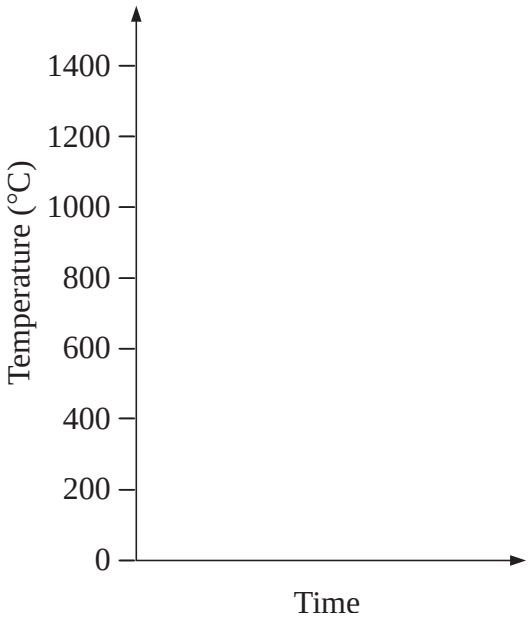


(a) (i) Using the axes provided below, sketch the equilibrium cooling curves and label the phases present for the following alloys, cooled from 1300°C. **3**

- 0·5% carbon
- 3·5% carbon



0·5% CARBON



3·5% CARBON

QUESTION 4. (Continued) **Marks**

(ii) Name the solid phase present, under equilibrium conditions, in a 2·5% carbon alloy at 1200°C, and determine its composition at that temperature.

Name ..... Composition .....

(b) (i) The equilibrium diagram provided shows two phases which are interstitial solid solutions. Name these TWO phases. **2**

1. .....

2. .....

(ii) State the maximum solid solubility of carbon in FCC iron.

.....

(iii) Iron–carbon alloys form interstitial solid solutions rather than substitutional solid solutions. State ONE reason for this.

.....

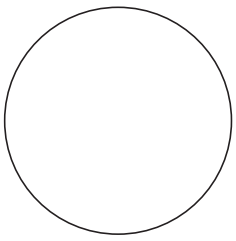
.....

(c) Explain the term *allotropic change.* Give an example from the iron–carbon phase diagram to illustrate your answer. **1**

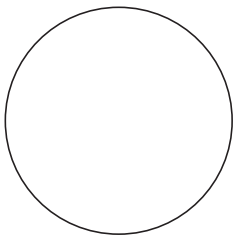
.....

.....

(d) Alloys of 0·5% carbon and 2·5% carbon in iron are cooled under equilibrium conditions to room temperature. Draw and label the resultant microstructures of these two alloys. **2**



0·5% CARBON ALLOY

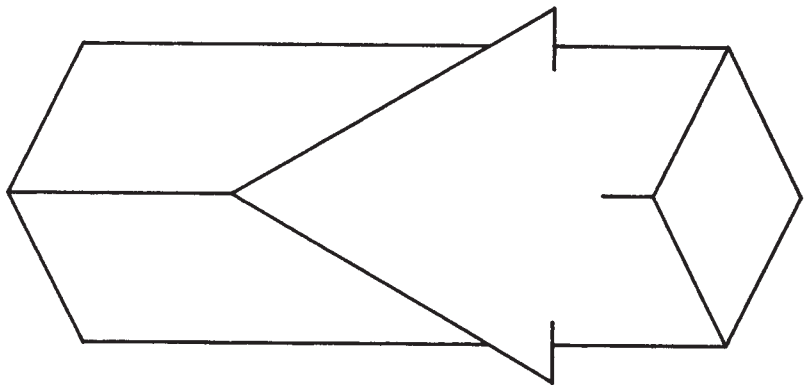


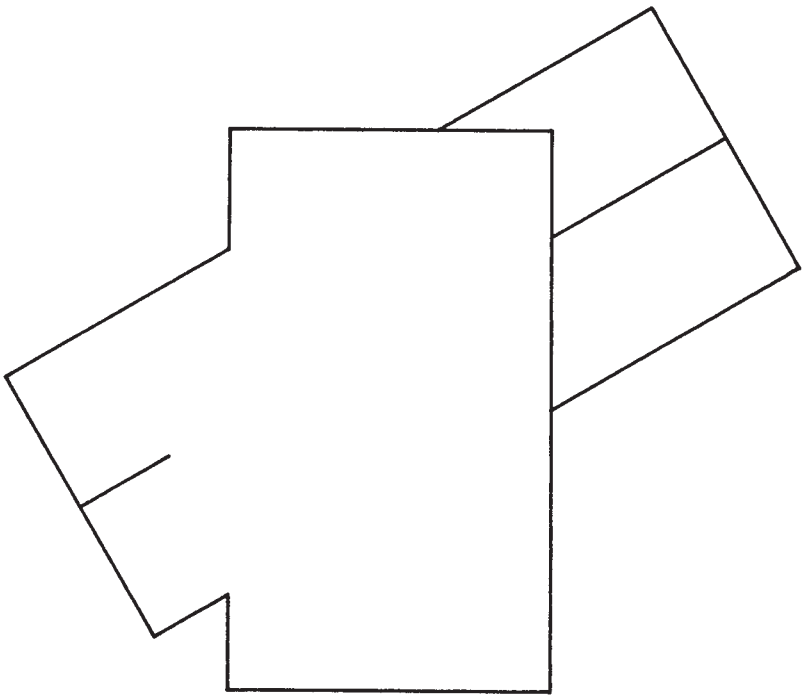
2·5% CARBON ALLOY

QUESTION 5 **Marks**

(a) The incomplete front view and incomplete top view of a square prism intersecting with a triangular prism are given below in third-angle projection. **3**

Complete the top view and the front view.

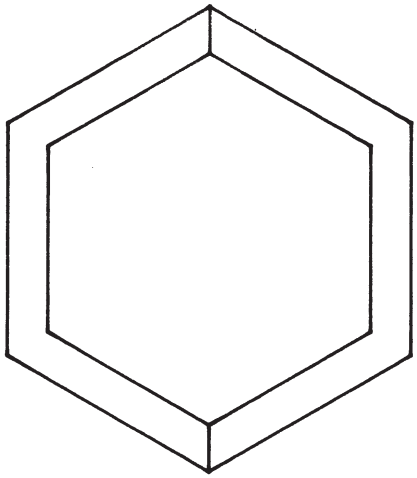


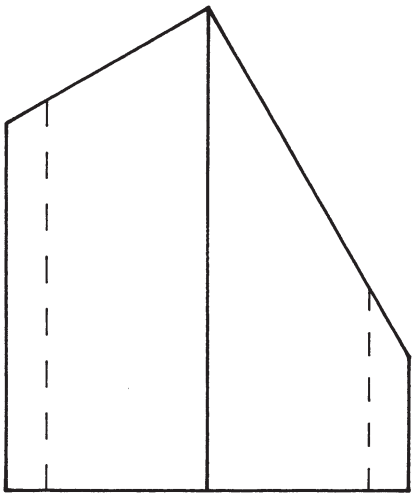


QUESTION 5. (Continued) **Marks**

(b) The top view and front view of a truncated hexagonal pipe are given below in third-angle projection. **5**

Project the right-side view of the pipe. Do NOT include hidden outline in your solution.

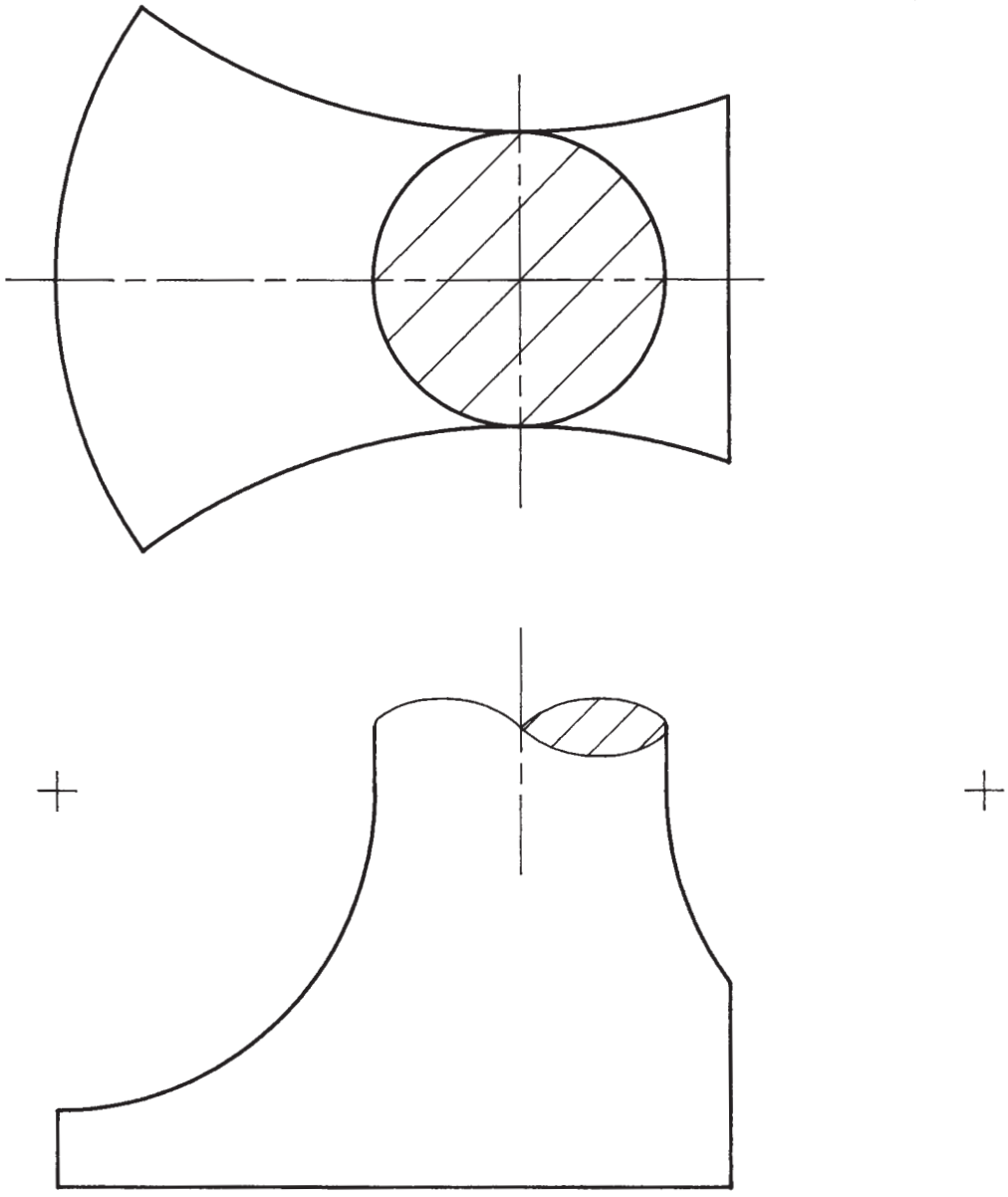




QUESTION 6 **Marks**

(a) The top view and incomplete front view of a rod end are given below in third-angle projection. **4**

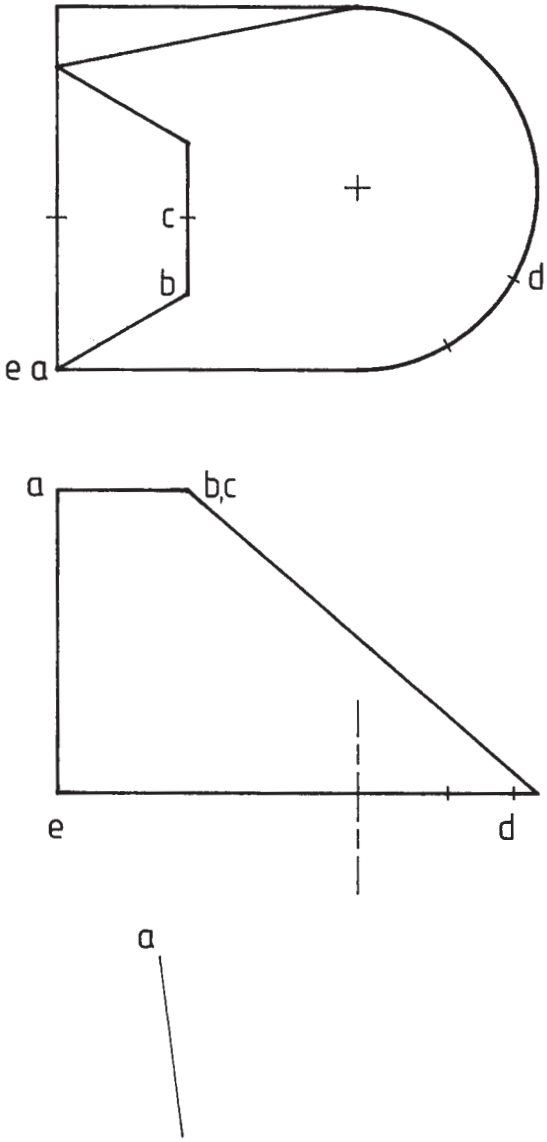
Complete the front view.



QUESTION 6. (Continued) **Marks**

(b) The top view and front view of a transition piece are given below in third-angle projection. **4**

Develop a surface pattern for the section abcde. Point, a, and part of the seam are given to start the pattern.



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BOARD OF STUDIES
NEW SOUTH WALES

STUDENT NUMBER

CENTRE NUMBER

HIGHER SCHOOL CERTIFICATE EXAMINATION

1998

ENGINEERING SCIENCE

2/3 UNIT (COMMON)

SECTION II

(52 Marks)

Total time allowed for Sections I and II—Three hours
(Plus 5 minutes reading time)

DIRECTIONS TO CANDIDATES

- Write your Student Number and Centre Number at the top right-hand corner of this page.
- Allow approximately 90 minutes for this Section.
- Attempt ALL questions.
- Answer the questions in the spaces provided in this paper. Set out your working clearly and neatly. Emphasis will be placed on that working when marks are allocated.
- Diagrams throughout this paper are to scale, unless otherwise stated.
- Drawing instruments and Board-approved calculators may be used.

MARKER'S USE ONLY

Question	Max. Marks	Marks Awarded	Marks Checked
7	8		
8	8		
9	8		
10	8		
11	8		
12	12		
TOTAL	Max. 52		

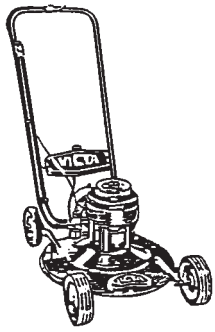
QUESTION 7 **Marks**

(a) Five examples of lawnmowers are given below. **4**

'Old Lawn Mowers', David Halford, Shire Publication, ISBN 0 832 636 075. Reproduced courtesy the author

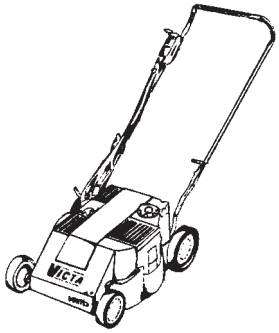
1907 RANSOME
FIG. 1

1910 MOWER
FIG. 2



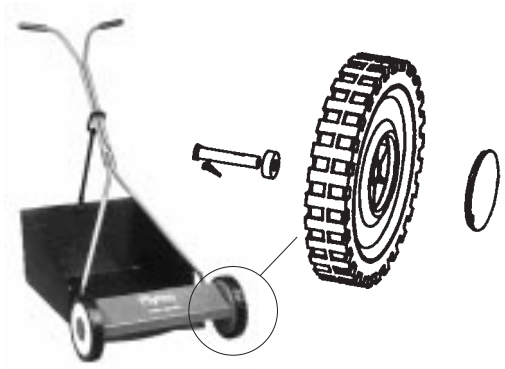
Victa manuals. Reproduced with permission of Universal Press Pty Ltd JD 11/98

1950s VICTA 2-STROKE
FIG. 3



Victa manuals. Reproduced with permission of Universal Press Pty Ltd JD 11/98

1980s VICTA VORTEX
FIG. 4



Electrolux Pty Ltd

1998 MOWER
FIG. 5

(i) State TWO social and/or environmental consequences that have resulted in the change from the mower in Figure 2 to the mower in Figure 3.

1. .....

2. .....

(ii) State TWO social and/or environmental factors that have influenced the change from the mower in Figure 3 to the mower in Figure 4.

1. .....

2. .....

(iii) The mower in Figure 1 used an indirect drive to rotate the cutting blades. The mowers in Figures 3 and 4 used a direct drive to rotate the cutting blades. List TWO advantages of the direct drive over the indirect drive. Do NOT use cost as an advantage.

1. .....

2. .....

QUESTION 7. (Continued) **Marks**

(iv) During the 1990s, the push-cylinder mower in Figure 5 has re-emerged as a popular design. State TWO social and/or environmental reasons for its recent popularity. Do NOT use cost as a reason.

1. .....

2. .....

(b) (i) The table below lists various components of push-cylinder mowers. Complete the table by suggesting a suitable material used for the components listed. **4**

Component	*1910 mower (Figure 2)*	*1998 mower (Figure 5)*
Handle		Low-carbon-steel tube
Wheel		
Bearing	Bronze bush	
Grass catcher		

(ii) Explain how a design feature of the mower in Figure 5 makes it safer to use than the mower in Figure 2.

.....

.....

.....

QUESTION 8 **Marks**

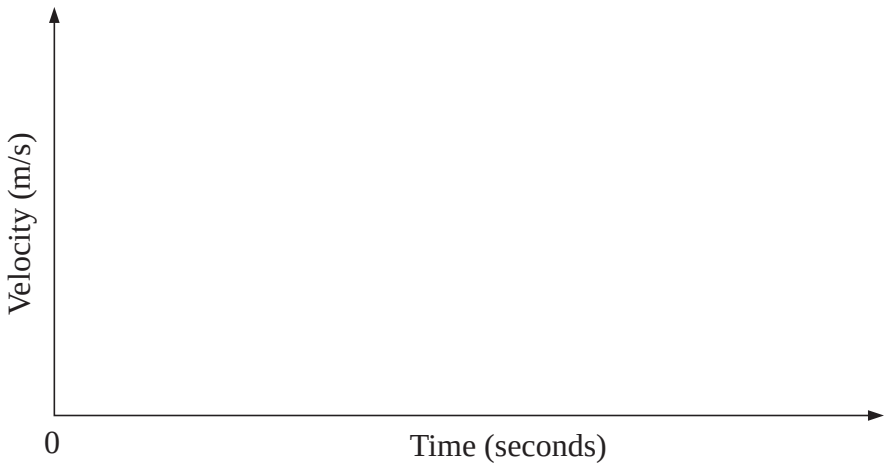
(a) A bicycle and rider accelerate from rest at 2 m/s^2 for a period of 10 seconds. The bicycle and rider then travel at a constant velocity before decelerating at 3 m/s^2 until they become stationary. The total distance travelled is 1 kilometre. **6**

(i) Determine the maximum velocity achieved by the bicycle and rider during the journey.

Maximum velocity ..... m/s

(ii) On the axes provided below, sketch the graph (*not to scale*) representing the journey. Label on your sketch the:

- maximum velocity
- time taken to reach the maximum velocity
- region representing constant velocity
- region representing deceleration.



(iii) Determine the distance travelled during the period of deceleration.

Distance travelled ..... m

QUESTION 8. (Continued) **Marks**

(iv) Determine the total time taken by the rider and bicycle to complete the 1 kilometre journey.

Total time ..... s

(b) Bicycle *A* is travelling in a north-easterly direction at 8 m/s. Bicycle *B* is travelling in a westerly direction at 3 m/s. **2**

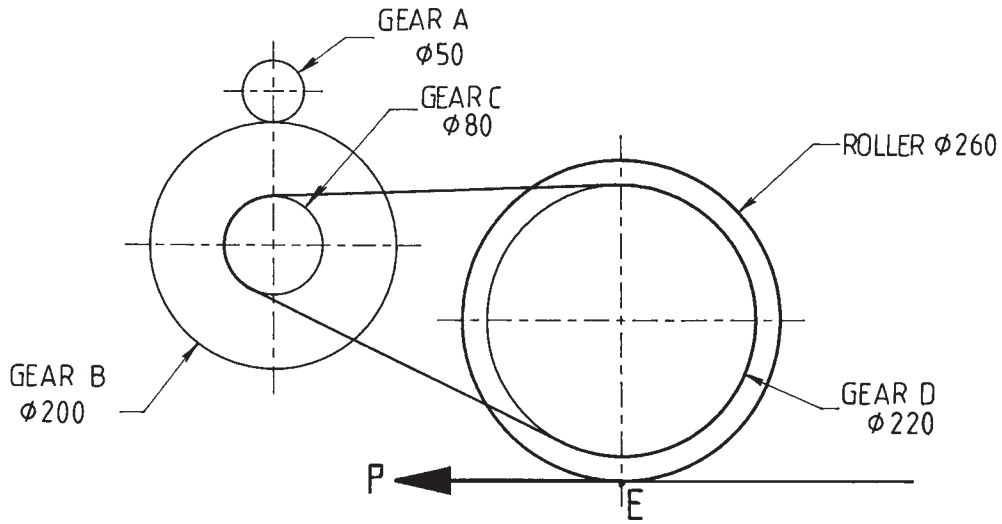
Determine the velocity and direction of bicycle *B* relative to bicycle *A*.

Relative velocity ..... m/s

Relative direction .....

QUESTION 9 **Marks**

The drive mechanism for a lawnmower is given. Gear A on the motor shaft rotates at 2400 r.p.m. and drives Gear B. Gear C uses a chain to drive Gear D on the roller. The diameter for each gear is given.



(a) (i) Determine the overall velocity ratio of A:D. **4**

V.R. .....

(ii) Determine the speed, in revolutions per minute, of Gear D.

.

Speed of Gear D ..... r.p.m.

(iii) The motor delivers 1·5 kW of power to the motor shaft. Determine the power transmitted to the gear on the roller if the system has an efficiency of 90%.

Power ..... kW

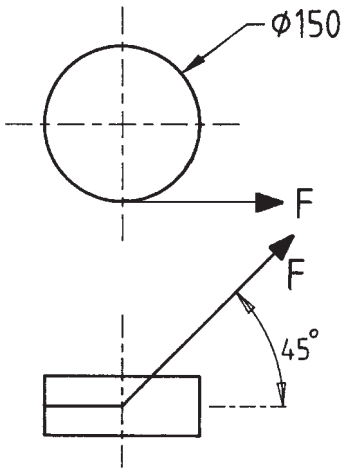
QUESTION 9. (Continued) **Marks**

(b) For a different motor output, the roller travels a distance of 80 m in 90 seconds. The tangential driving force P, at point E, is 500 N. Determine the power transmitted by the system. **2**

Power ..... W

(c) The starter cord of a lawnmower is connected to the recoil-start mechanism as shown below. **2**

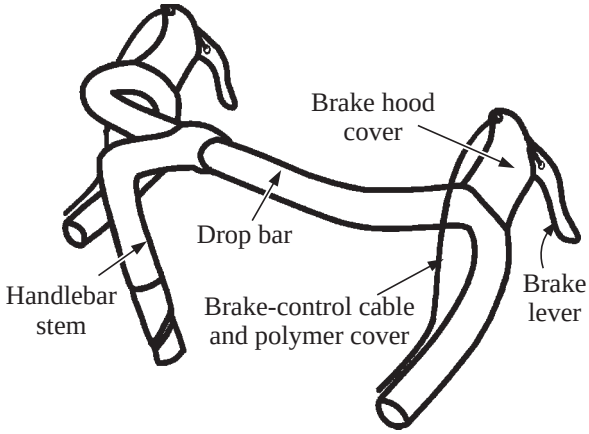
Determine the minimum force F, on the starter cord if a torque of 5·9 N m is required to start the motor. The mechanism is 90% efficient.



Force F ..... N

QUESTION 10 **Marks**

A pictorial drawing of a bicycle handlebar is shown below.



InterAccess Co

(a) The brake hood cover is manufactured by injection moulding from high-density polyethylene. **$2\frac{1}{2}$**

(i) Describe the injection moulding process.

.....

.....

.....

(ii) An alternative material for the brake hood cover is polystyrene formed by compression moulding. What effect does temperature and pressure have in this process?

.....

.....

(iii) Name and describe a process that may be used to form the polymer cover for the brake-control cable.

Name of process .....

Description .....

.....

.....

(b) (i) The drop bar and the handlebar stem are made from 0·7% carbon steel tube. State ONE advantage and ONE disadvantage of using this steel compared to an aluminium alloy. Do NOT use cost as a consideration. **3**

Advantage .....

Disadvantage .....

QUESTION 10. (Continued) **Marks**

(ii) The drop bar of the bicycle is plated with a thin layer of chromium. State TWO reasons why the drop bar is plated.

1. .....

2. .....

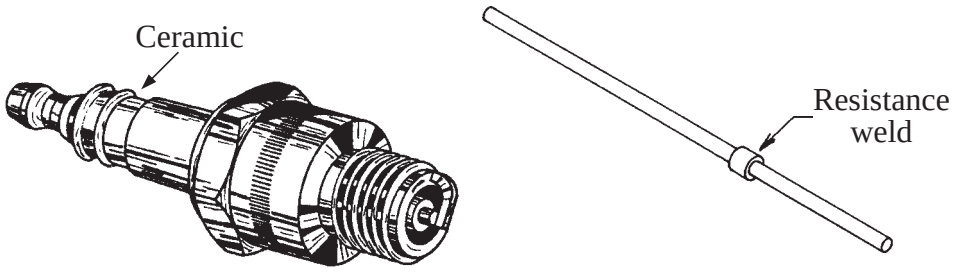
(iii) Name a cold-working process that would be used in forming the shape of the drop bar from extruded 0·7% carbon steel tube.

.....

(iv) Give ONE reason why a cold-working process is used rather than a hot-working process to form the drop bar.

.....

(c) A spark plug and the central electrode are shown below.



Spark plug Central electrode

(i) State TWO service properties of the ceramic used in the spark plug. **$2\frac{1}{2}$**

1. .....

2. .....

(ii) Suggest a clay-bodied ceramic that may be used.

.....

(iii) The central electrode is a two-part component which is resistance welded. Describe this welding process.

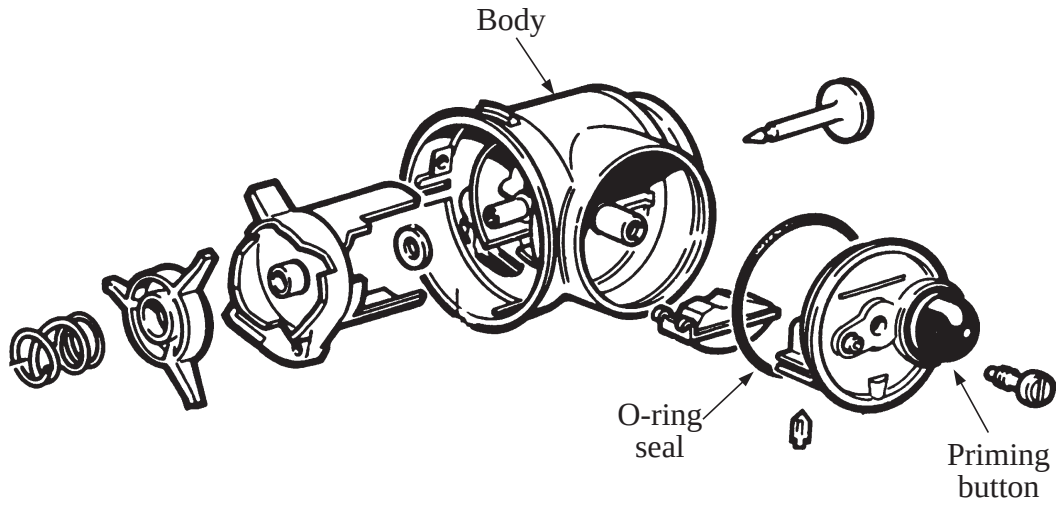
.....

.....

.....

QUESTION 11 **Marks**

A pictorial assembly diagram of a lawnmower carburettor is shown below. The body is made from 30% glass-filled polyester. The priming button and the O-ring seal are made from neoprene rubber.



Victa Carburretor brochure. Reproduced courtesy Universal Press.

(a) (i) List TWO service properties of the composite material used for the body. **3**

1. .....

2. .....

(ii) What is the purpose of adding 30% glass fibre to the polyester material used to make the body?

.....

.....

.....

(iii) Name the process and the additive used to change the properties of rubber to make it suitable for the O-ring seal.

Name of process .....

Additive .....

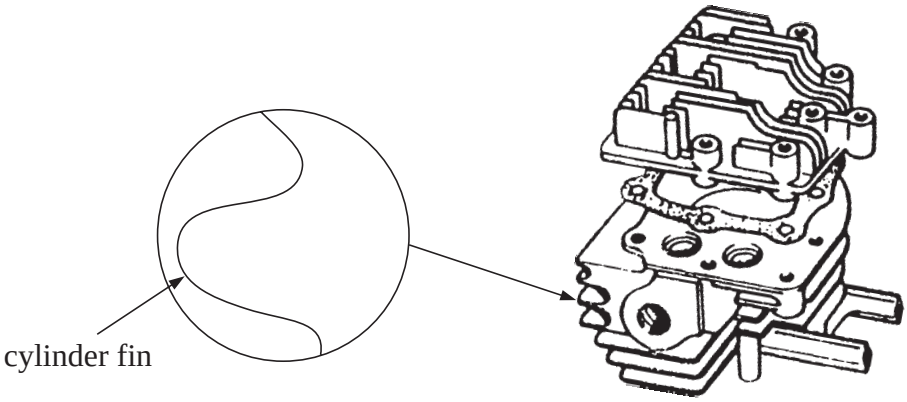
(iv) Over a period of time in service, the rubber in the priming button is exposed to the atmosphere. State the effect that this exposure could have on the properties of the rubber.

.....

.....

QUESTION 11. (Continued) **Marks**

(b) The cylinder body and cylinder head of a lawnmower engine are shown below. The cylinder body is manufactured by sand casting of cast iron. **3 1/2**



Victa Casting brochure. Reproduced courtesy Universal Press

(i) On the enlarged portion of a cylinder fin, sketch and label the grain structure that results from sand casting.

(ii) Cylinder heads are manufactured by die casting of aluminium alloys. State TWO advantages of die casting over sand casting.

1. .....

2. .....

(iii) During some sand casting processes, sand cores may be used. State TWO reasons for using sand cores.

1. .....

.....

2. .....

.....

(c) (i) Brazing is used to join the frame of a low-carbon-steel bicycle. State TWO reasons for the use of a flux during the brazing process. **1 1/2**

1. .....

2. .....

(ii) State the main difference between hard soldering and gas welding.

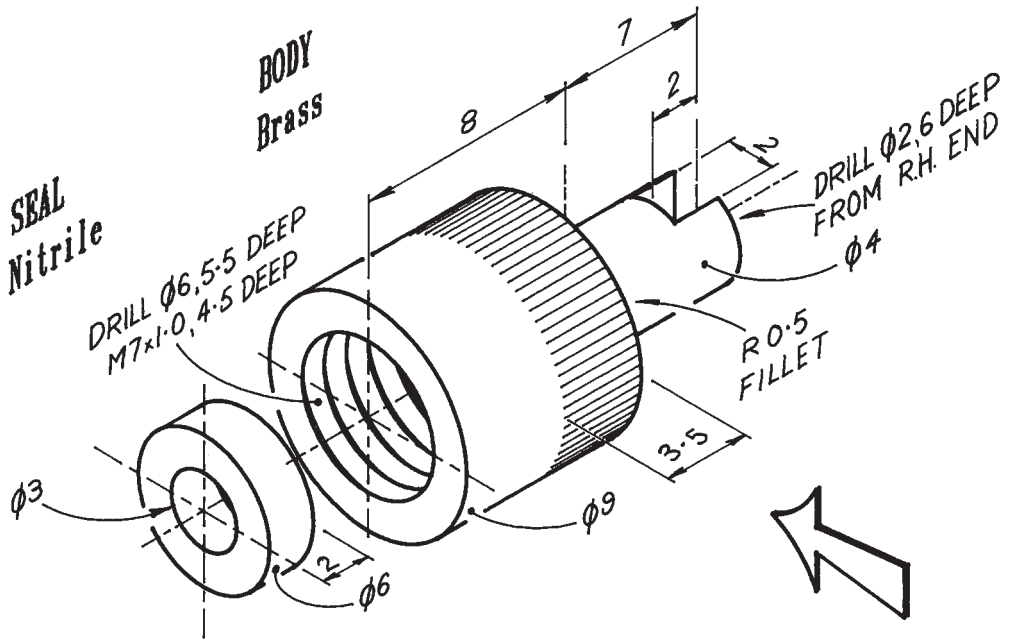
.....

.....

QUESTION 12 **Marks**

The shape and size details of a bicycle valve cap are given below in the exploded pictorial drawing. The valve cap is also used to remove the valve from the stem. **12**

Draw, to a scale of 5:1, a half-sectional front view of the assembled parts when viewed from the direction of the arrow. The centre line is given for the drawing.



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1998
HIGHER SCHOOL CERTIFICATE EXAMINATION
ENGINEERING SCIENCE
2/3 UNIT (COMMON)

Not to be collected at the conclusion of the examination.

FORMULAE

Dynamics

$v = u + at$

$s = ut + \frac{1}{2}at^2$

$s = \left(\frac{u+v}{2}\right)t$

$v^2 = u^2 + 2as$

$F = ma$

$I = Ft = m(v-u)$

$M = mv$

$KE = \frac{1}{2}mv^2$

$PE = mgh$

$SE = \frac{1}{2}kx^2$

$F = kx$

$P = \frac{W}{t}$

$W = Fs$

Statics

If a body is in equilibrium, then :

$\sum F_x = 0; \quad \sum F_y = 0; \quad \sum M = 0$

$M = Fd; \quad F = \mu N$

Machines

$MA = \frac{L}{E}; \quad VR = \frac{d_E}{d_L}; \quad \eta = \frac{output}{input} = \frac{MA}{VR}$

Strength of materials

$\sigma = \frac{P}{A}; \quad \varepsilon = \frac{e}{L}; \quad E = \frac{\sigma}{\varepsilon}; \quad \%RA = \frac{A_0 - A}{A_0} \times 100; \quad FS = \frac{\sigma_{\text{yield}}}{\sigma_{\text{working}}}$

Area of circle

$A = \frac{\pi}{4}d^2$

Circumference of circle

$C = \pi d$

ROUGH WORK SHEET

Not to be collected at the conclusion of the examination.