CANDIDATE NAME

CLASS

INDEX NUMBER

Section B			
Q10	Q11	Q12E	Q12O

Section B (30 marks)
Answer all questions in this section.
Answer only one of two alternative questions in **Question 12**.

10 Optical fibre is used extensively to transmit internet data around the world, as an estimated 2.5×10^9 Gigabytes of data is created and accessed each day.

Fig. 10.1 shows a cross-sectional view of an optical fibre used for such data transmission. Internet data, in the form of light ray travels through the cylindrical glass core, that is surrounded by a layer of cladding. A light ray enters from air into the core at point P.

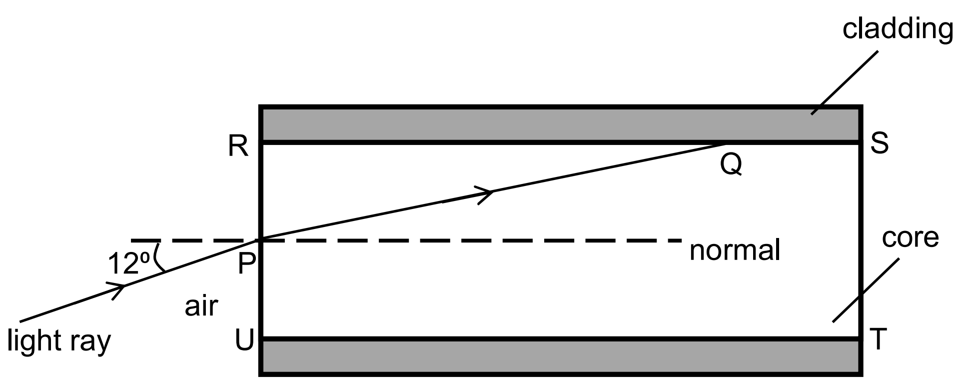

Fig. 10.1 (not to scale)

During the design of a particular optical fibre, various materials for the core and cladding are considered. Fig. 10.2 shows a list of materials, and their refractive indices.

Core material	Refractive index
A	1.53
B	1.49
C	1.40
D	1.42
E	1.56

Cladding material	Refractive index
V	1.44
W	1.41
X	1.36
Y	1.52
Z	1.50

Fig. 10.2

(a) State what is meant by the term *critical angle*.

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

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

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

(b) One of the core materials from Fig. 10.2 is being considered.

A ray of light that enters at P with an angle of incidence of 12° travels into this core, and subsequently makes an angle of incidence along surface MN at 82°.

Assuming that the cross section of the core RSTU is a rectangle, calculate the refractive index of this core material, and identify the material chosen by referring to Fig. 10.2.

core material = ………………………….. [2]

(c) Next, material C is being considered for the core, with the same light ray entering P at an angle of incidence of 12°.

(i) Calculate the speed of light that travels through C.

speed = ………………………….. [2]

(ii) From Fig. 10.2, select a suitable cladding to be used with C.

Using ideas about angle of incidence, critical angle, and refractive index, explain how your selection of cladding allows a ray of light travelling from P to Q to be reflected off RS.

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……………………………………………………………………………………

……………………………………………………………………………………[2]

(iii) A student suggests that the critical angle (θ_c) of light for C in **(c)(ii)** can be obtained by applying the formula:

$$\sin \theta_c = \frac{1}{n}$$

where n is the refractive index of material C.
Provide a reason why the student's suggestion cannot be used here.

……………………………………………………………………………………

……………………………………………………………………………………[1]

(iv) Two different incident rays, R1 and R2, enter material C at the same point P. R1 has a lower angle of incidence than R2, and both rays reflect off RS.

Compare how the time taken for light to travel from the surface RU to ST is affected when R1 or R2 is chosen. Explain your answer.

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……………………………………………………………………………………[2]

11 An engineer conducted an experiment to verify the principle of moments using a set-up shown in Fig. 11.1.

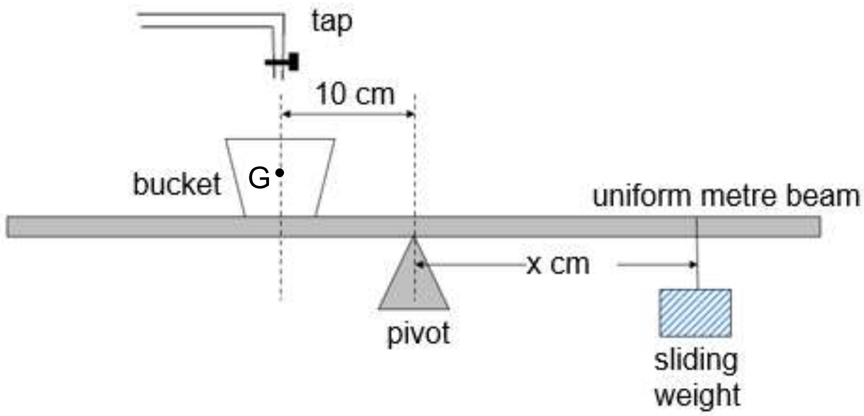

Fig. 11.1

A 20 g bucket is placed on a uniform metre beam which is pivoted at the 50.0 cm mark. The centre of gravity of the empty bucket is at point **G**. Water of density 1.0 g/cm^3 is released into the bucket at a constant rate of 40 cm^3 per minute. In order to balance the beam, a 50 g sliding weight hung on the beam is adjusted accordingly by the engineer.

(a) Define the principle of moments.

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…………………………………………………………………………………………………

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

(b) The tap is turned on for 5.0 minutes. During this period of time, the position of the sliding weight is adjusted continuously to keep the beam horizontal. At the end of the 5.0 minutes, the sliding weight is a distance **x** from the pivot.

(i) It is found that the pivot is exerting a 4.0 N force on the beam. Calculate the weight of the beam.

weight = ……………………….. [2]

(ii) Calculate **x**.

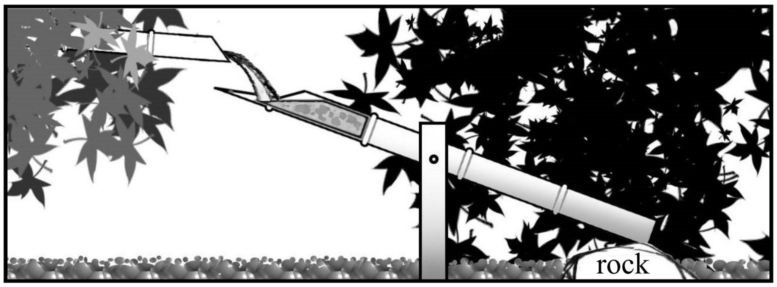
x = ……………………….. [2]

(c) Explain why the set up will not be able to achieve equilibrium, if the bucket holds more than 230 g of water.

…………………………………………………………………………………………………

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

(d) The engineer modified the set-up and created a device similar to a Sozu fountain, a type of water fountain displayed in Japanese gardens as shown in Fig. 11.2. It consists of a tube that is pivoted at a point. Its lower end rests against a rock as shown while the upper end has a cavity used to hold water.



https://en.wikipedia.org/wiki/Shishi-odoshi

Fig. 11.2

Water from the tap flows into the cavity at the upper end of the tube as shown in Fig. 11.3(a). The water that has accumulated eventually causes the tube to rotate and water flows out of the cavity when this happens.

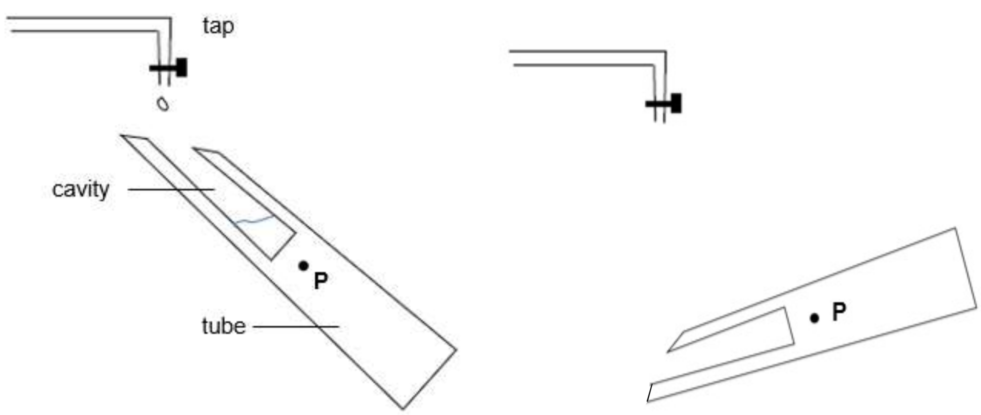


Fig. 11.3(a) **Fig. 11.3(b)**

(i) Describe how the centre of gravity of the tube and the water changes as water flows into the empty cavity until it finally rotates.

………………………………………………………………………………………………

………………………………………………………………………………………………

……………………………………………………………………………………… [2]

(ii) In another Sozu fountain which is faulty, after the water has been emptied, the tube remains in the position as shown in Fig. 11.3 (b).
State the position of the centre of gravity of the faulty fountain and explain your answer.

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……………………………………………………………………………………… [2]

12E Fig. 12.1 shows a fire detection circuit designed by a student. The bell will ring when the NTC thermistor detects high temperatures. The bell has a resistance of 4.0 Ω and is designed to operate normally at 12.0 V. A magnetic switch which comprises of a switch and a coil is used to close the circuit automatically when there is a fire.

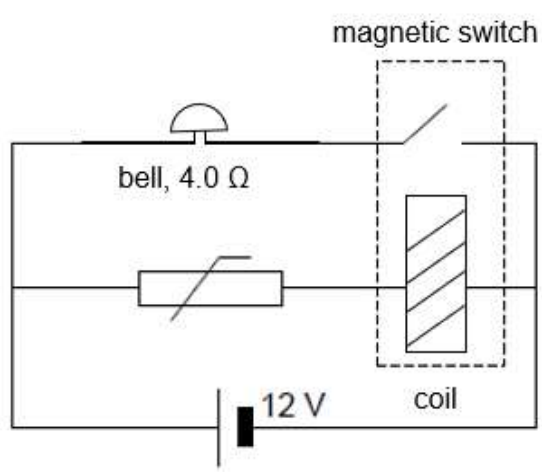

Fig. 12.1

(a) Explain why the bell is an output transducer.

………………………………………………………………………………………………

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

(b) Explain why the bell will not ring when there is no fire.

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…………………………………………………………………………...…….[3]

(c) During a test, the temperature is increased causing the magnetic switch to close. When this happens, the current through the coil is 0.050 A and the potential difference across the coil is 4.0 V.

(i) Calculate the resistance of the thermistor at this instant.

resistance = …………………….…….. [2]

(ii) Determine the total current drawn from the 12.0 V supply.

total current = ………………………… [2]

(d) The student modified the circuit and connected the bell to two identical filament lamps in parallel as shown in Fig. 12.2(a) and in series as shown in Fig. 12.2(b).

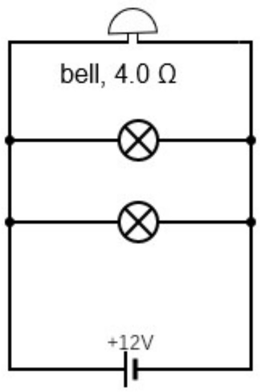

Fig. 12.2 (a)

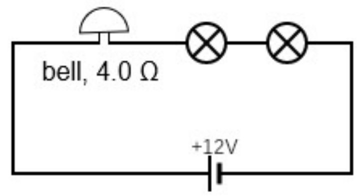

Fig. 12.2 (b)

After taking some measurements, the student discovered that the resistance of the identical lamp is lowered when it is connected in series to the bell as shown in Fig. 12.2(b). Explain why this occurs.

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

12O Fig. 12.3 shows a rotating permanent magnet in an alternating current generator ("dynamo"). The dynamo is used to power a lamp.

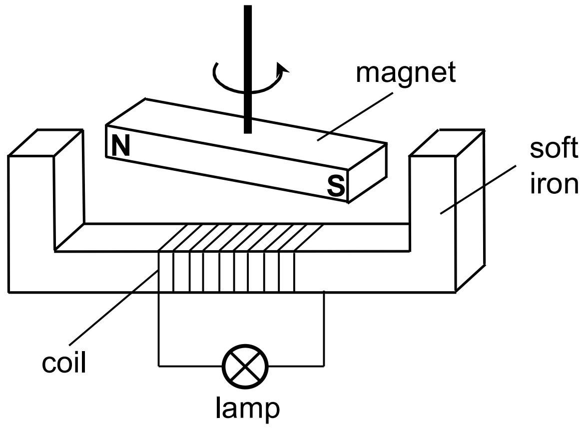

Fig. 12.3

(a) **(i)** State what is meant by an *alternating current*.

....

.... [1]

(ii) Explain why a current is induced in the coil of the dynamo.

....

.... [1]

(iii) Explain why the induced current is alternating.

....

....

.... [2]

(iv) State two ways that the induced current in the lamp might be increased.

1. ....

2. .... [2]

(b) The primary input voltage is 23 000 V, and the secondary output voltage is stepped up to 660 000 V before it is transmitted over long distance.

(i) Explain why the voltage needs to be stepped up for transmission.

....

.... [1]

(ii) The current in the primary coil is 100 A. Find the power generated in the primary coil.

primary coil power = ………………….. [1]

(iii) Assuming that the transformer is ideal, find the current in the secondary coil.

current = ………………….. [1]

(iv) The transmission cable has a total resistance of 2 000 Ω. Find the power loss in the transmission cable.

power loss = ………………….. [1]

END OF PAPER