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PHYSICS

2007

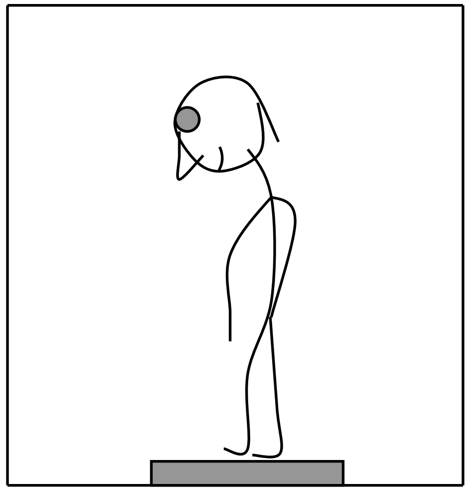
Trial Examination 1

Motion in one and two dimensions
Electronics and photonics
Investigating materials and their use in structures

(Note: Use information in the formula data sheet supplied by VCAA)

Area of study 1 − Motion in one and two dimensions

Tom (mass of 75 kg) measures his weight inside a moving elevator by standing on an accurate bathroom scale that is calibrated in kilogram. The reading shown on the scale is 72 kg. Take $g = 10$ N kg^{-1}.



Question 1
Calculate the apparent weight of Tom inside the moving elevator. 2 marks

N

Question 2
Which **one or more** of the following statements **cannot** be true regarding the motion of the elevator? 2 marks

A. The elevator moves downwards with increasing speed.

B. The elevator moves downwards with decreasing speed.

C. The elevator moves upwards with increasing speed.

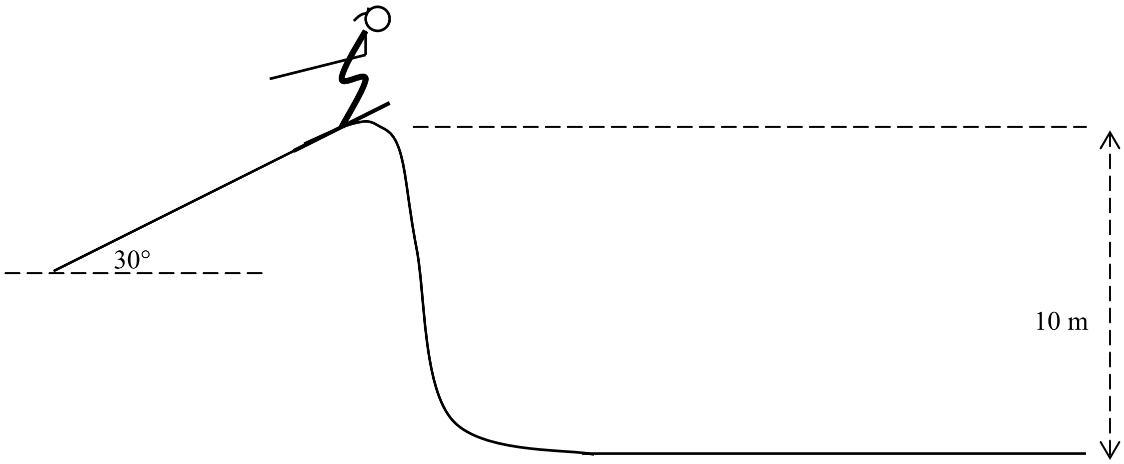
D. The elevator moves upwards with decreasing speed.

E. The elevator is a non-inertial frame of reference.

Question 3
Calculate the magnitude of the acceleration of the moving elevator. 3 marks

ms^{-2}

Tom skies off from the cliff edge at 20 ms^{-1}. Take g = 10 N kg^{-1}. See the diagram below for other data. Ignore air resistance.



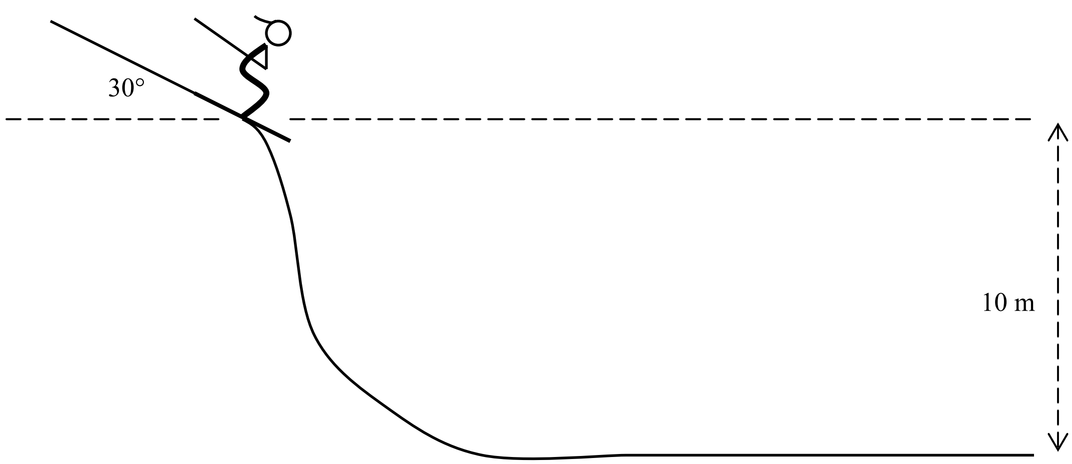
Question 4
Calculate the time between taking off and landing. 3 marks

seconds

Question 5
Calculate Tom's speed just before landing. 3 marks

ms^{-1}

Tom is about to sky off from another cliff edge at the same speed 20 ms^{-1}. Take g = 10 N kg^{-1}. See the diagram below for other data. Ignore air resistance.



Question 6
Which one of the following statements is true when the second jump is compared with the first jump? 2 marks

A. Tom will take longer time to land at a higher speed.

B. Tom will take shorter time to land at a higher speed.

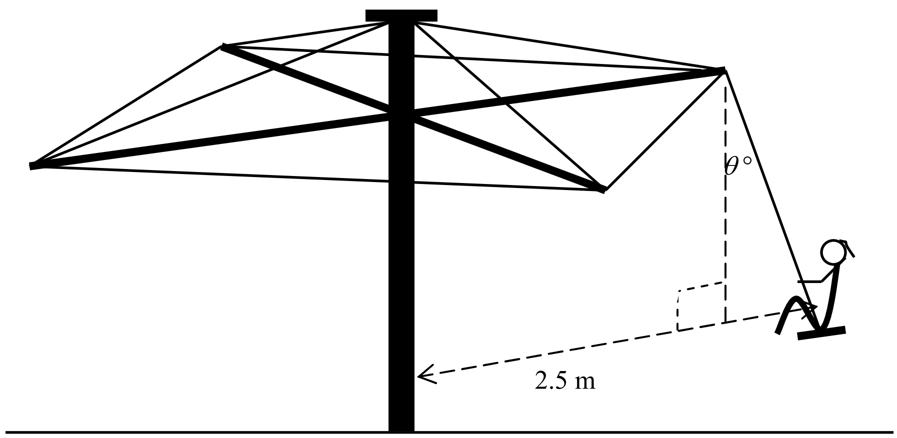
C. Tom will take longer time to land at a lower speed.

D. Tom will take shorter time to land at a lower speed.

E. Tom will take longer time to land at the same speed.

F. Tom will take shorter time to land at the same speed.

Tom junior (25 kg) uses the rotary hoist in the backyard as a merry-go-round rotating at 2.0 ms^{-1}. Take g = 10 N kg^{-1}. See the diagram below for other data. Ignore air resistance.



Question 7
On the diagram above draw arrows (correct relative length and direction) to represent the two 'real' forces acting on Tom junior.

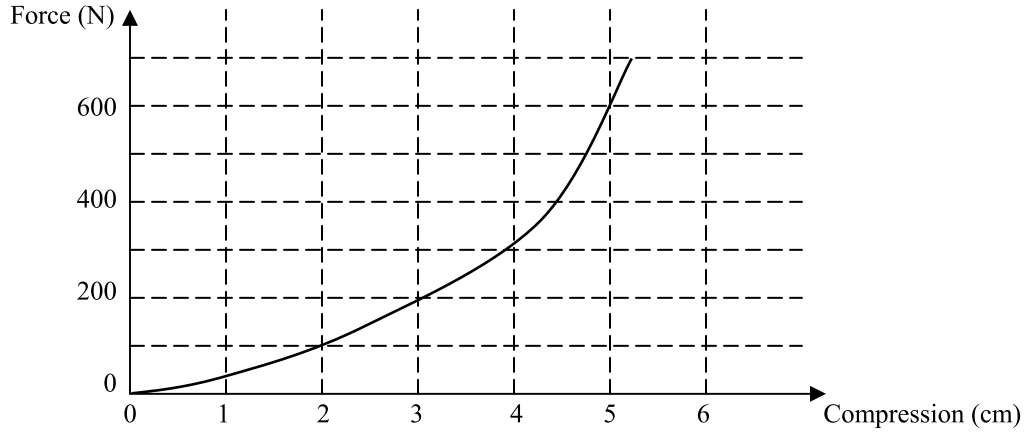
2 marks

Question 8
Calculate the net force on Tom junior. 3 marks

N

Question 9
Calculate the angle $\theta°$ that the rope makes with the vertical. 2 marks

Tom found a spring in his garage. He investigated the force-compression relationship of the spring, which is shown in the following graph.

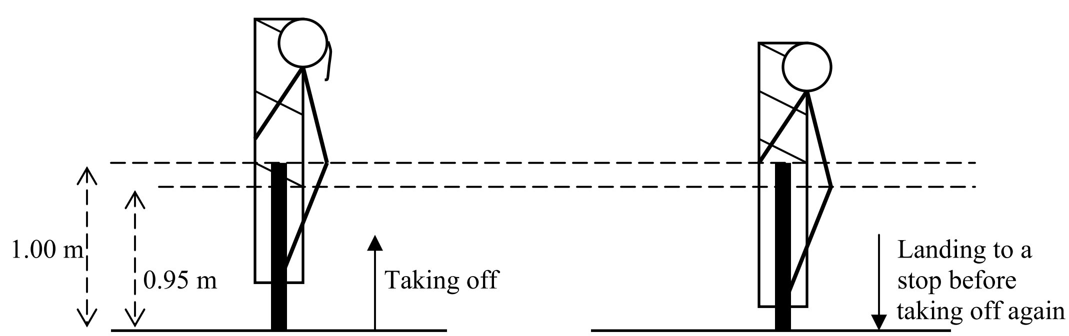


Question 10

Estimate the amount of work required to compress the spring by 5.0 cm. 3 marks

J

Tom made a pogo-stick out of the spring and some pipes for Tom junior. The total mass of Tom junior and the pogo-stick is 27 kg. In the next question heights are measured from the ground to the centre of mass of Tom junior and the pogo-stick. Tom junior was upright all the time during a vertical hop. Take $g = 10$ N kg^{-1}. See the diagram below for other data. Ignore air resistance and friction.



Question 11

Tom junior's hair is missing in the second diagram above. Draw his hair pointing in the correct direction in the second diagram.

1 mark

Question 12

Calculate the maximum possible speed of Tom junior at take off. 3 marks

ms^{-1}

Question 13
At the moment just before Tom junior and the pogo-stick taking off again, which one of the following statements is true? 2 marks

A. The acceleration of Tom and the pogo-stick is zero.

B. The net force on Tom and the pogo-stick is pointing downwards.

C. The net force on Tom and the pogo-stick is pointing upwards.

D. The net force on Tom and the pogo-stick is at its minimum.

Tom and Tom junior decide to go space travel for A$5,000,000. They are in a space ship travelling in circular orbit around the earth, completing one revolution in 12 hours.

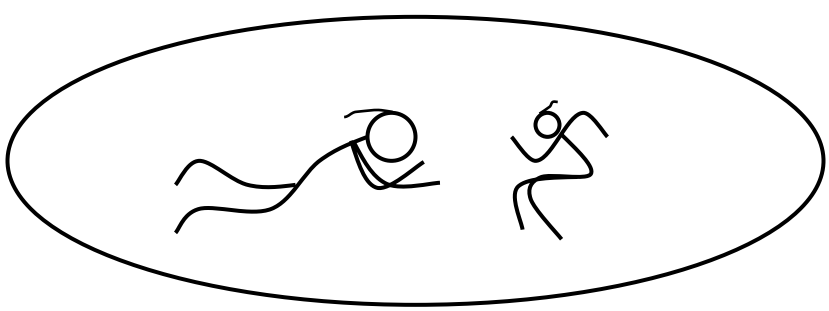
Question 14
Calculate the speed of the space ship relative to the centre of the earth. 3 marks

ms^{-1}

Question 15
Calculate Tom's weight while he is in orbit around the earth. 3 marks

N

Tom (75 kg) and Tom junior (25 kg) are at rest inside the space ship. Tom pushes Tom junior with an average force of 5.0 N for 1.2 s.

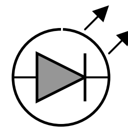


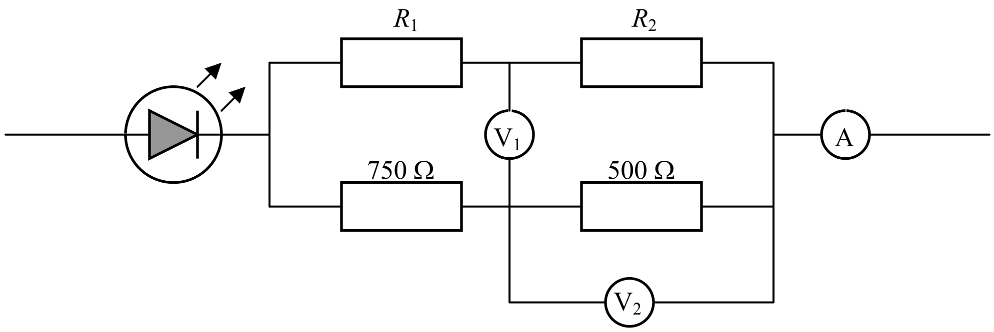
Question 16
Calculate the speed of Tom junior relative Tom when they are apart. 3 marks

ms^{-1}

Area of study 2 − Electronics and photonics

The following diagram shows a small part of a complicated circuit, where

(A) and (V) represent ammeter and voltmeter respectively,  an ohmic resistor, and  a LED.

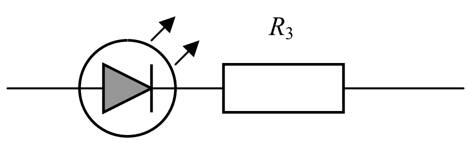


The meter readings are V_1 = 0 volts, V_2 = 2.4 volts and A = 10.8 milli-amperes.

Question 1

Determine the value of the ratio $\frac{R_1}{R_2}$. 3 marks

The above circuit (with the meters removed) can be simplified to the one shown below, where the same LED is used.



Question 2

Calculate the value of R_3. 3 marks

Ω

Question 3
Refer to the original circuit. If there is a short circuit across the 750 Ω resistor, which one of the following statements is correct?

2 marks

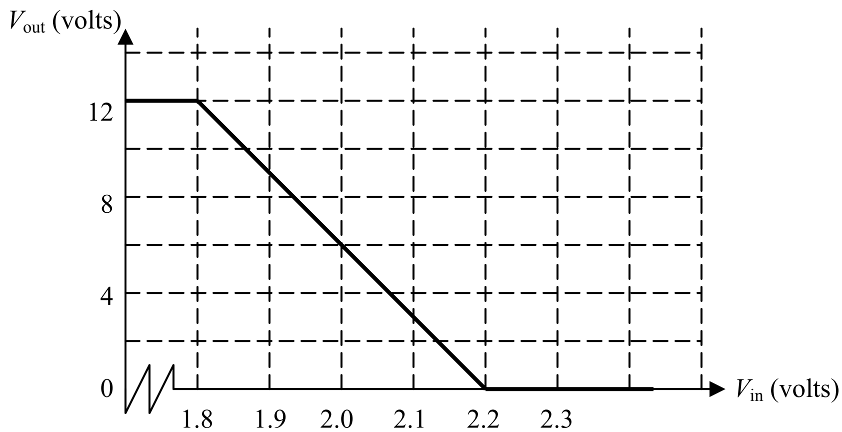
A. The voltage across the LED will be significantly higher.

B. The voltage across the LED will be significantly lower.

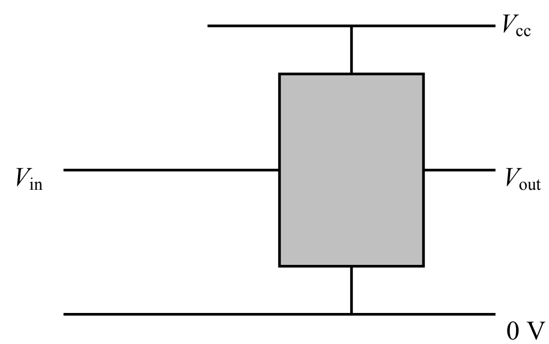
C. The voltage across the LED will **not** change significantly.

D. The LED will be damaged by a stronger current.

The following graph shows the operational characteristics of a single stage npn transistor amplifier.



The rectangle in the following circuit diagram represents the single stage npn transistor amplifier.



Question 4
Calculate the signed voltage gain of the amplifier.

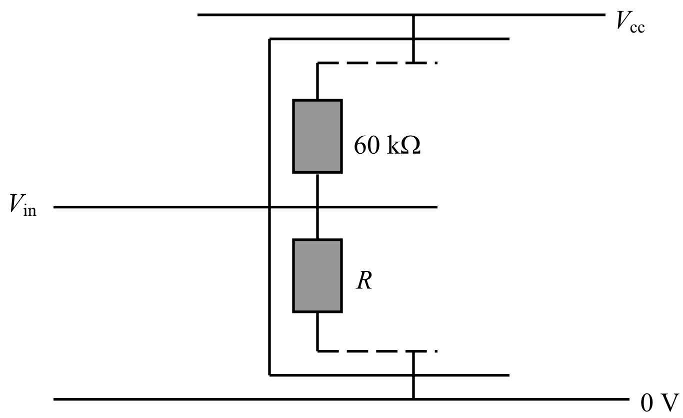
2 marks

Question 5
Complete the following table.

3 marks

Value of V_{cc}	volts
Value of maximum peak-to-peak input signal without causing clipping of the output signal	volts
V_{out} at saturation	volts

Inside the amplifier is a voltage divider for correct biasing of the base voltage of the npn transistor.

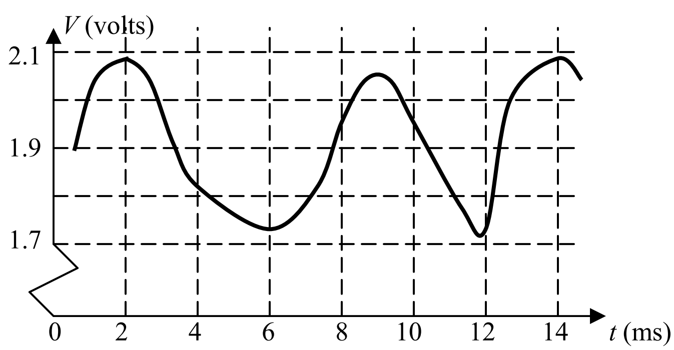


Question 6

Calculate the resistance of R. 3 marks

kΩ

A signal to be amplified is shown in the following graph.

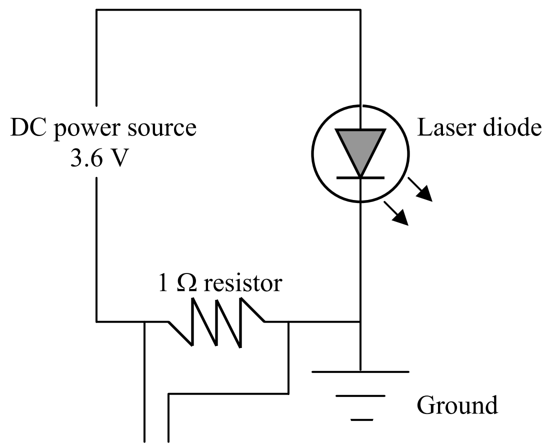


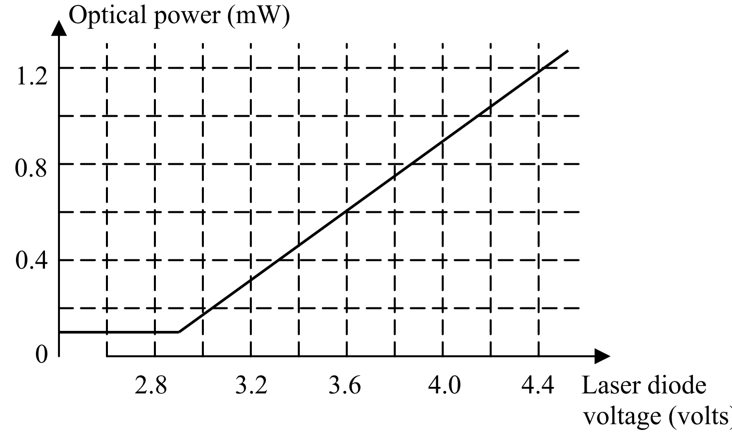
Question 7

What has to be done to ensure that the signal is centred at the linear-operating range of the amplifier to prevent clipping of the signal?

3 marks

The following is a schematic diagram of a simple opto-electronic converter. This device sends out information in analogue form using intensity modulated light. The accompanying graph shows the optical power output of the laser diode at different voltages.





Question 8

Explain the meaning of '*This device sends out* ***information*** *in* ***analogue form*** *using* ***intensity modulated light***', especially the highlighted terms, in the introduction.

3 marks

Question 9

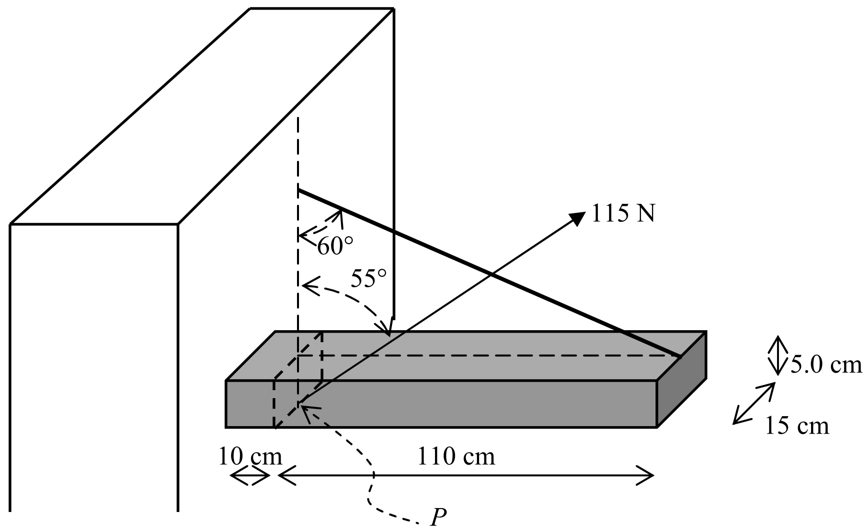
Signal from the CD player causes a change in voltage across the laser diode by ± 0.10 volts. Determine the variation in the optical power output of the laser diode.

3 marks

± mW

Detailed study 2 − Investigating materials and their use in structures

A uniform wooden plank is held in horizontal position by having one end embedded in a wall and the other end by a cable. There is a reaction force of 115 N from the wall on the plank at 55° to the vertical. Take $g = 10 \text{ N kg}^{-1}$. See the diagram below for other data.



Question 1
Calculate the compressive stress and the shear stress at point *P*. 4 marks

Compressive Nm^{-2}	Shear Nm^{-2}

Question 2
Calculate the tension in the cable. 2 marks

N

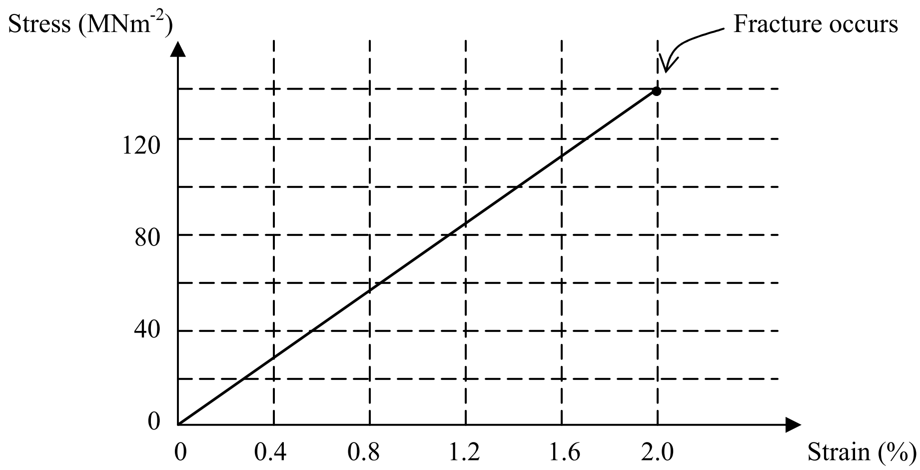
Question 3
Calculate the mass of the wooden plank. 2 marks

kg

Question 4
What is the net torque on the wooden plank about point *P*? 2 marks

Nm

A sample of ordinary glass is tested under tension until it fractures. The stress-strain graph is shown below.



Question 5
Complete the table below. 3 marks

Tensile strength	MNm^{-2}
Young's modulus	MNm^{-2}
Strain energy	MJm^{-3}

Question 6
State a feature of the stress-strain graph above that indicates brittleness of ordinary glass. 1 mark

Question 7
Which one of the following properties is **common** for diamond, ordinary glass and table jelly? 2 marks

A. Tough

B. Brittle

C. Plastic

D. Stiff

E. Strong

Car windscreen is toughened glass. It is made by chilling the hot glass by means of air jets until the outside is hardened while the inside is still soft.

Question 8
Explain how the manufacturing process toughens the glass in terms of tension and compression. 4 marks

Fibre-glass is a composite material consisting of glass and resin. Both resin and ordinary glass are brittle materials but fibre-glass is much tougher. A particular type of fibre-glass (e.g. fibre-glass fishing rods) has a tensile strength of 1000 MNm^{-2} and Young's modulus of 35000 MNm^{-2}.

Question 9
Calculate the resulting strain when a tensile stress of 2.1 MNm^{-2} is exerted on the particular type of fibre glass. 2 marks

| %
|---|

Question 10
Explain why the composite material fibre-glass is much tougher than the component materials. 3 marks

