

Student name

PHYSICS

Unit 3

Trial Examination

QUESTION AND ANSWER BOOK

Total writing time: 1 hour 30 minutes

Structure of book

Section	Number of questions	Number of marks
A - Core areas of study		
1. Motion in One and Two Dimensions	16	40
2. Electronics and Photonics	10	25
B - Detailed studies		
1. Einstein's Special Relativity	11	25
OR 2. Investigating Materials and their use in structures	9	25
OR 3. Further Electronics	12	25
Total		90

- Students are permitted to bring into the examination room: pens, pencils, highlighters, erasers, sharpeners, rulers, up to two pages (one A4 sheet) of pre-written notes (typed or handwritten) and an approved graphics calculator (memory cleared) and/or one scientific calculator.
- Students are NOT permitted to bring into the examination room: blank sheets of paper and/or white out liquid/tape.

Materials supplied

- Question and answer book of 34 pages, with a detachable formula sheet in the centrefold.

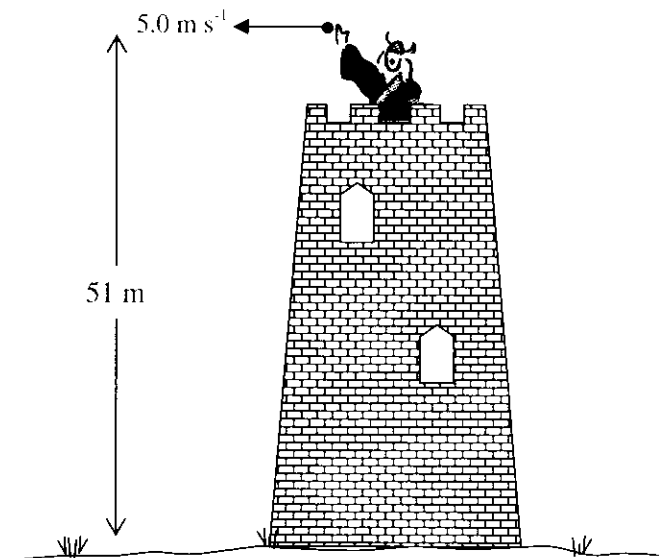
Instructions

- Detach the formula sheet from the centre of this book during reading time.
- Write your **name** in the space provided above on this page.
- Answer all questions in this question and answer book where indicated.
- Always show your working where space is provided and place your answer(s) to multiple-choice questions in the box provided.

Area of study 1 – Motion in one and two dimensions

Questions 1 to 4 relate to the following information.

Rapunzel throws a note to her lover wrapped around a rock weighing 2.0 kg, from the top of her tower where her evil guardian has her imprisoned. The rock leaves her hand with a horizontal velocity of 5.0 m s^{-1} . She releases the rock at a height of 51 metres above the ground. (Air resistance can be ignored)

**Question 1**

How long does it take for the rock to reach the ground?

[2 marks]

Question 2

What is the **speed** of the rock as it impacts the ground?

[3 marks]

Question 3

At what angle to the horizontal does the rock hit the ground?

[2 marks]

Question 4

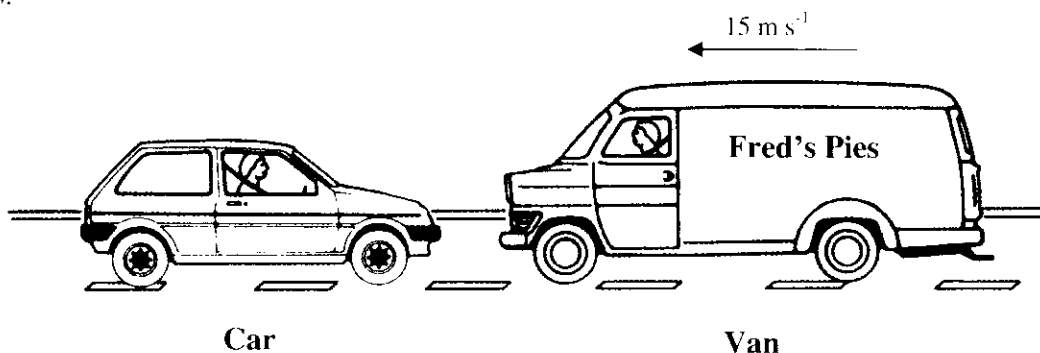
If Rapunzel had dropped the rock from her tower at a height of 51 m and not thrown it, when the rock is 10.2 m from the ground what is the ratio of the rock's potential energy to its kinetic energy if air resistance is neglected?

- A. 1:5 B. 1:4 C. 1:2 D. 4:1 E. 5:1

[2 marks]

Questions 5 to 7 relate to the following information.

The diagram given below shows a collision about to happen. The speed limit on this section of suburban street is 50 km h^{-1} . The vehicles crash head-on and stop locked together in approximately 0.20 seconds. The police know that the van has a mass of 2200 kg. From the van's tachymeter (a black box that records the vehicles speed) the police know that the van was travelling with a speed of 15 m s^{-1} at the instant of the collision. The car has a mass of 910 kilograms.



Question 5

What was the magnitude of the **van's** momentum just prior to the collision?

kg m s⁻¹

[2 marks]

Question 6

Was the car exceeding the speed limit? Show reasoning to prove your answer.

(Assume the truck and car form a closed system.)

[4 marks]

Question 7

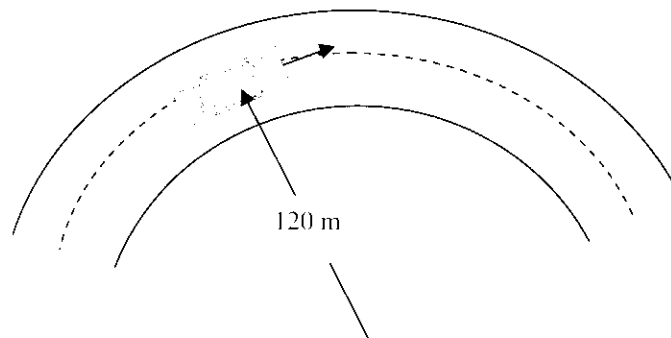
Fortunately nobody was injured in the collision. From the information given what was the magnitude of the average force applied to the **driver** of the van (mass of driver = 60 kg) during the collision?

N

[3 marks]

Questions 8 & 9 relate to the following information.

A car is travelling at constant speed around a right hand bend. The driver feels as if he is forced outwards as the car travels around the bend. The bend in the road is a section of a circle of radius 120 metres.



Question 8

Explain why the driver experiences an 'outwards force' as the car travels around the bend.

[2 marks]

Question 9

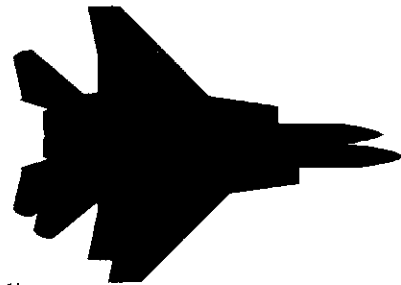
This 'outwards force' is found to be the equivalent of 0.30 of the driver's weight force.
What is the constant speed of the car?

m s^{-1}

[3 marks]

Question 10

An aircraft is flying at an airspeed of 600 km/h at constant altitude. There is a wind blowing in a northerly direction at 40 km/h.



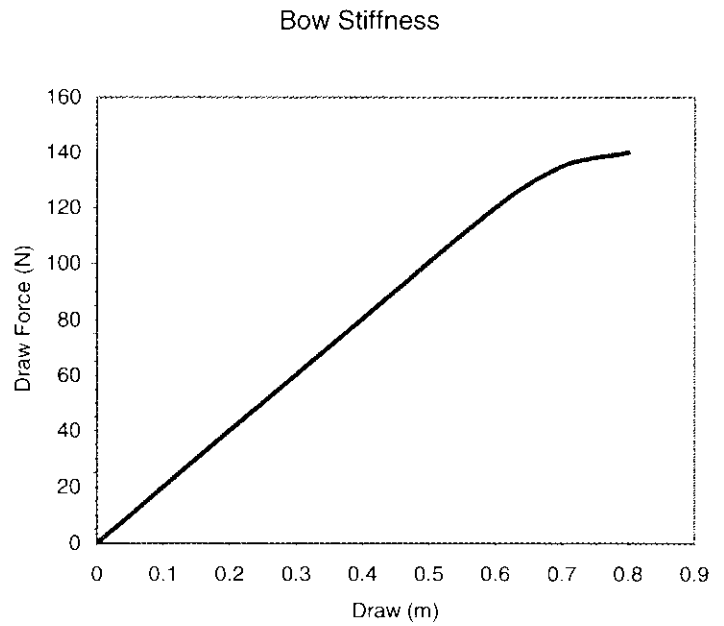
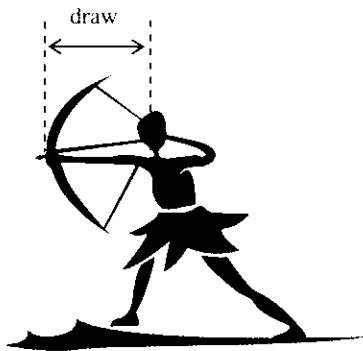
Along what bearing must the pilot steer to maintain a heading of due East? (Show your working and include a vector diagram.)

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[3 marks]

Questions 11 & 12 relate to the following information.

An archer is firing arrows of mass 100 g using a simple homemade bow. This bow has a draw force versus draw extension graph as shown on the right.



Question 11

What is the 'stiffness' value of this homemade bow?

N m^{-1}

[2 marks]

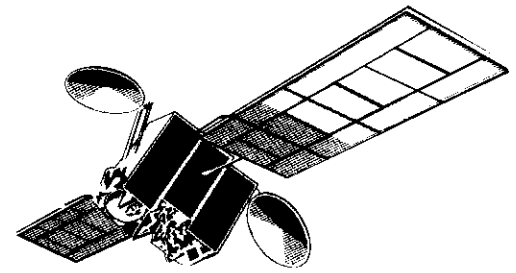
Question 12

Show that if the archer draws the bow back to an extension of 60 cm the maximum kinetic energy that can be given to the arrow on release is 36 J.

[2 marks]

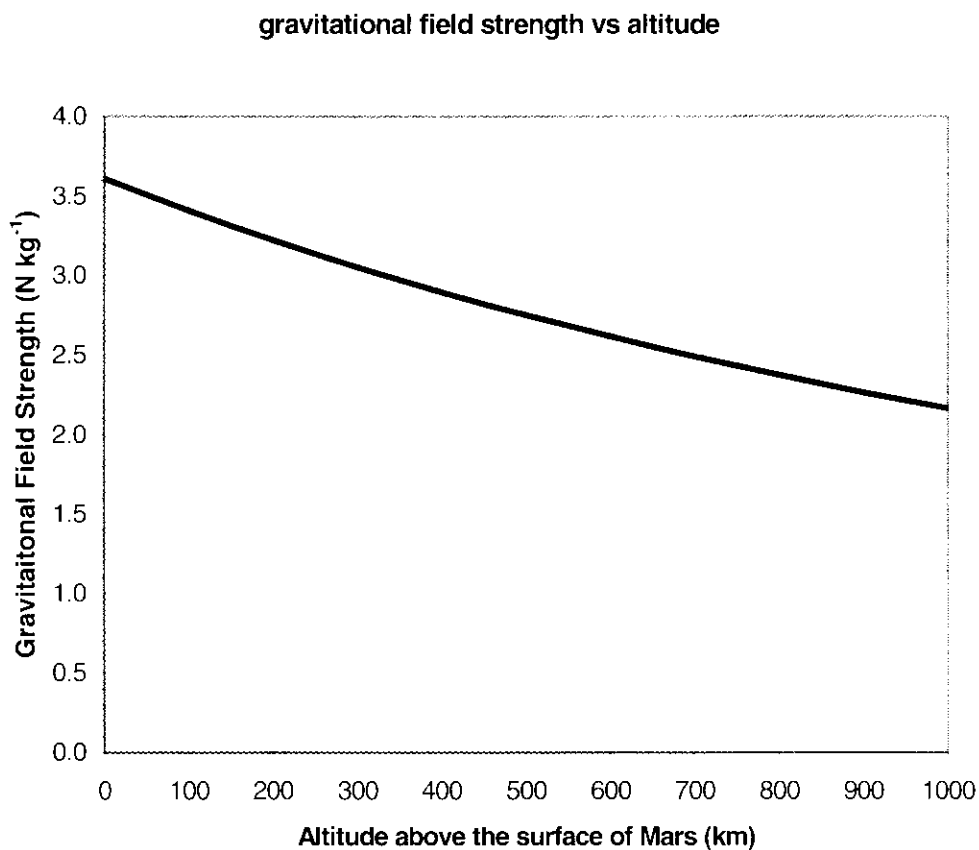
Questions 13 to 16 relate to the following information.

Mass of Mars $M_m = 6.37 \times 10^{23}$ kg
Radius of Mars $r_m = 3.43 \times 10^6$ m
Mass of Mars space craft and Endeavour = 650 kg
Mass of Endeavour = 150 kg



The scientists at NASA have proposed a new mission to Mars. They intend to send a spacecraft to Mars and then deploy a surface explorer called Endeavour. Endeavour will be sent to the surface while the spacecraft stays in a stable orbit to act as a communications relay satellite at a distance of two Mars radii ($2 \times r_m$) **above** the surface of Mars

A graph of the gravitational field strength of Mars is given below.



Question 13

If the gravitational field strength at the surface of Mars is g_m then the gravitational field strength acting on the communications satellite is best given as:

- A** $\frac{g_m}{2}$ **B** $\frac{g_m}{4}$ **C** $\frac{g_m}{3}$ **D** $\frac{g_m}{9}$ **E** g_m

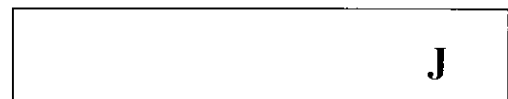
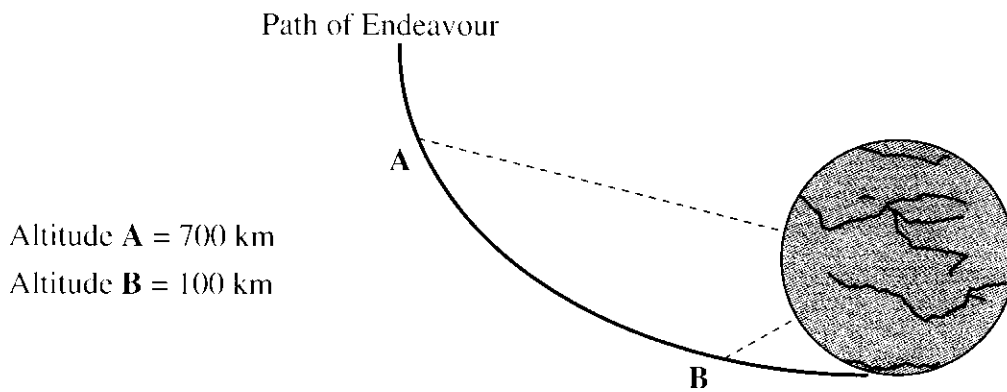


[2 marks]

Question 14

As the Endeavour is sent to the surface it passes through an altitude of 700 km (Point A) to an altitude of 100 km (Point B) where some braking rockets are employed.

Use the gravitational field strength graph of Mars to determine the increase in kinetic energy of the Endeavour as it passes from point A to point B.



J

[3 marks]

Question 15

What is the weight of the Endeavour on the surface of Mars?

N

[2 marks]

Question 16

What is the time taken for the spacecraft to orbit Mars when in it is in position to act as a relay satellite?

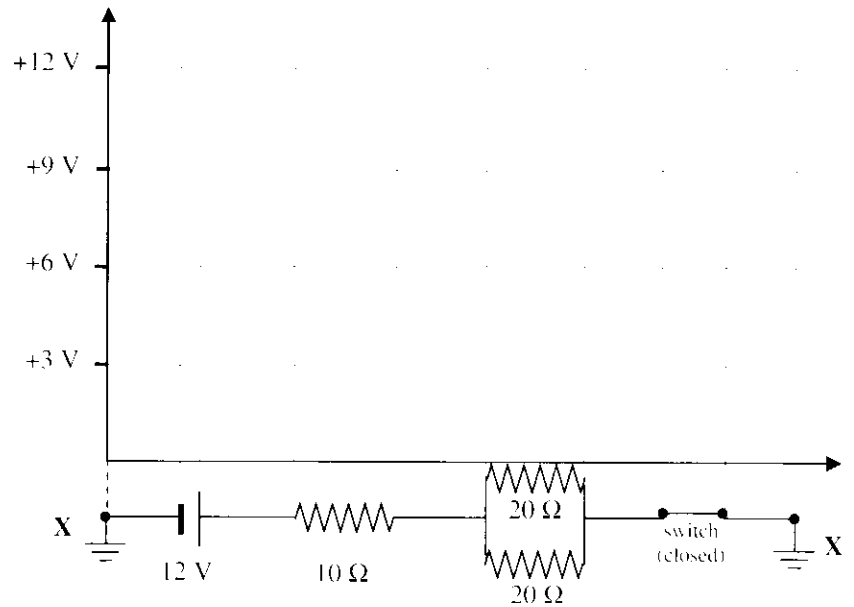
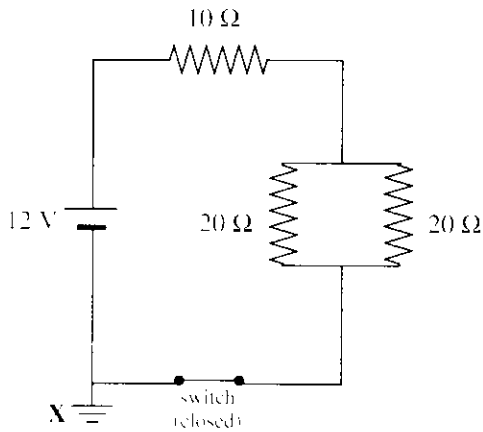
S

[3 marks]

Area of study 2 – Electronics and photonics

Question 1

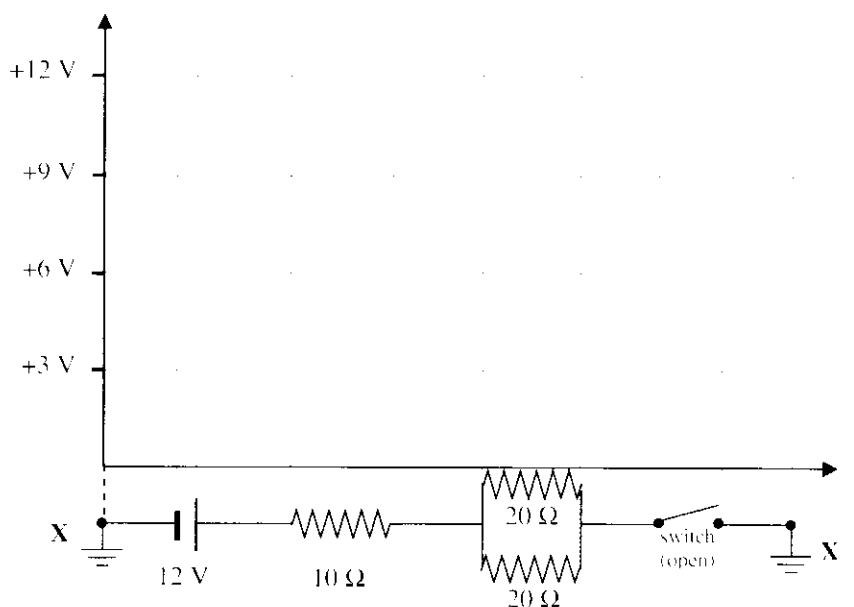
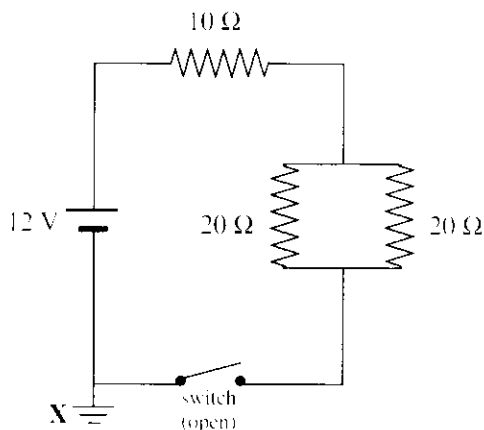
For the following circuit plot the potential difference (V) as a function of position from the point X, around the given circuit.



[3 marks]

Question 2

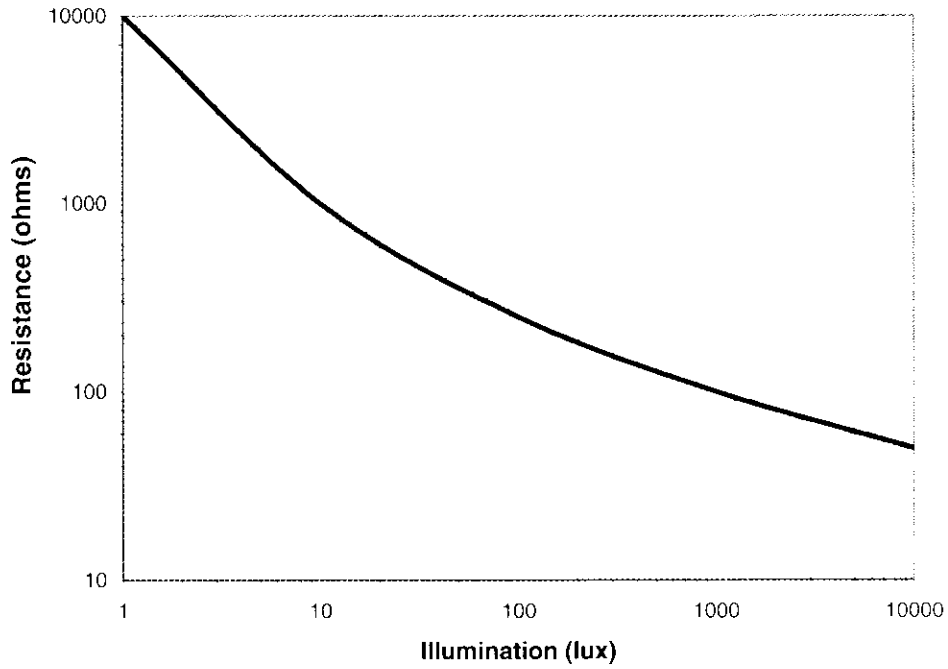
For the following circuit plot the potential difference (V) as a function of position from the point X, around the given circuit.



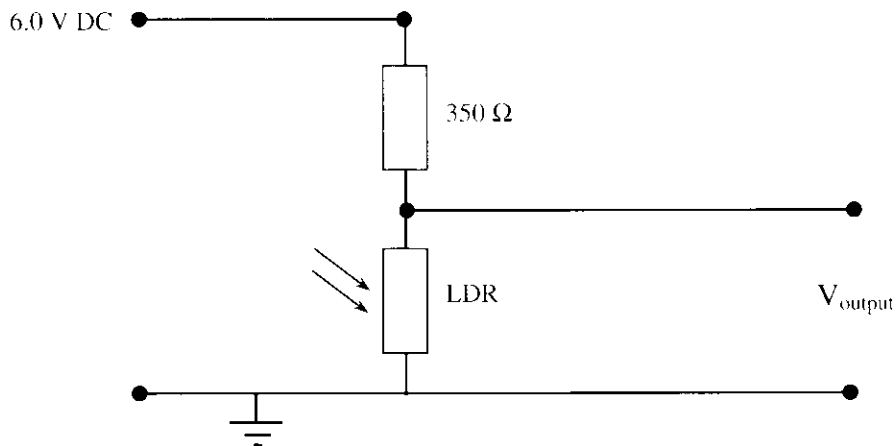
[3 marks]

Question 3

A light Dependent resistor has the following resistance versus illumination characteristic graph.



The LDR is placed in the following circuit.



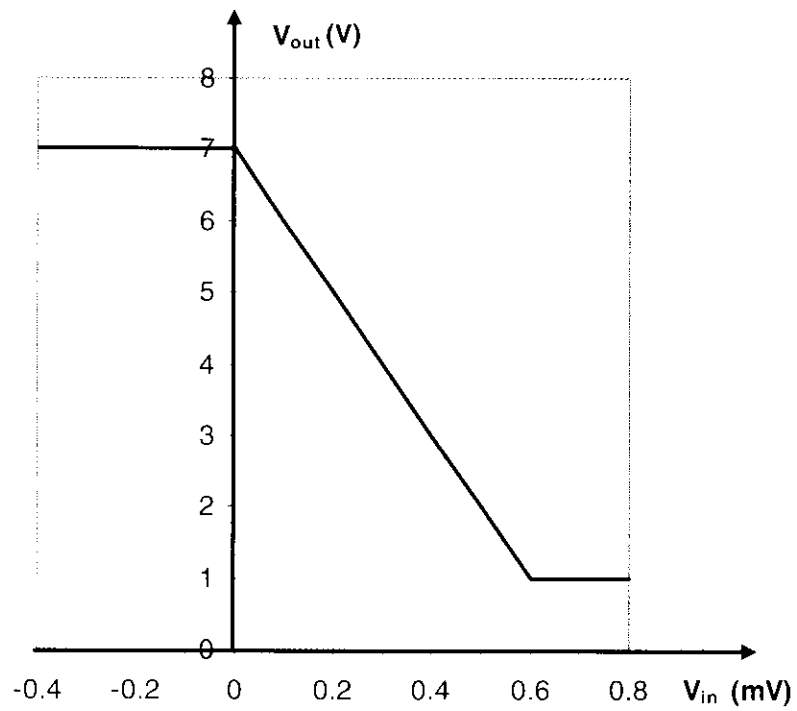
What is the output voltage of the circuit if the LDR is illuminated by light with an intensity of 40 Lux?

V

[2 marks]

Questions 4 to 8 relate to the following information.

The operational characteristic of a voltage amplifier is given below.



Question 4

What is the voltage gain of this amplifier?

[2 marks]

Question 5

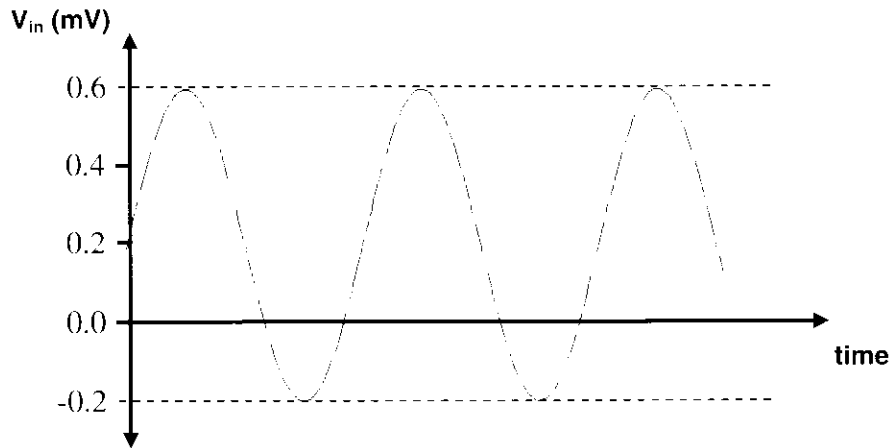
This amplifier is described as an ‘inverting amplifier’. Explain what the term **inverting** means in this context.

[2 marks]

Question 6

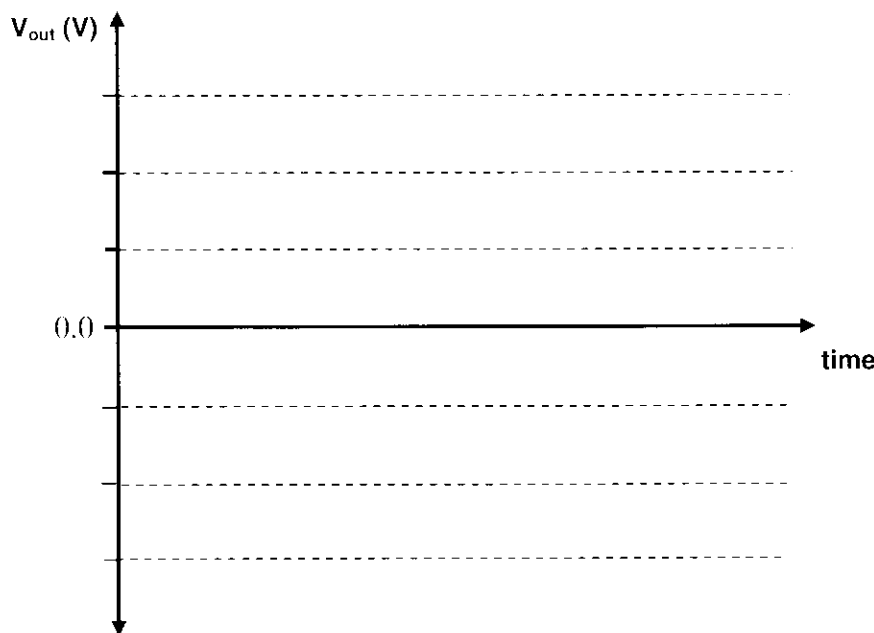
The following input signal (V_{in}) is fed into this amplifier.

Input



On the axes below sketch the likely output voltage (V_{out}) for the above input signal. Label the V_{out} axis accordingly.

Output



[3 marks]

Question 7

The input and output signals are both sinusoidal AC voltages and as a result both have frequencies. What is the value of the following ratio?

$$\frac{\text{frequency of } V_{\text{in}}}{\text{frequency of } V_{\text{out}}}$$

[2 marks]

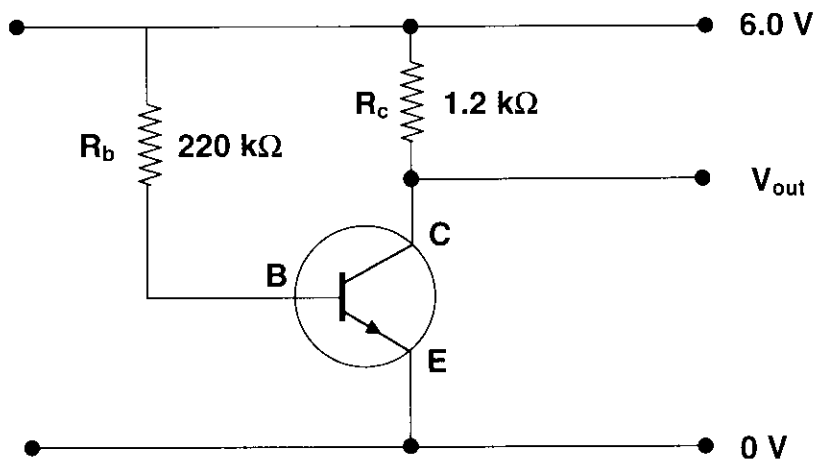
Question 8

The amplifier is to be biased to zero millivolts. Explain what the term 'bias' means in this context and what voltage should be applied to the input voltage to 'zero' bias this amplifier?

[3 marks]

Questions 9 & 10 relate to the following information.

A transistor amplifier is made from a silicon *npn* Bipolar Junction Transistor as shown in the following circuit. The current gain of this amplifier is 150. Take the value of $V_{BE} = 0.70 \text{ V}$.



Question 9

What is the value of the base current I_B ? Give your answer in μA .

μA

[2 marks]

Question 10

What is the output DC voltage at the collector?

V

[3 marks]

Detailed study 2 – Investigating materials and their use in structures

Question 1

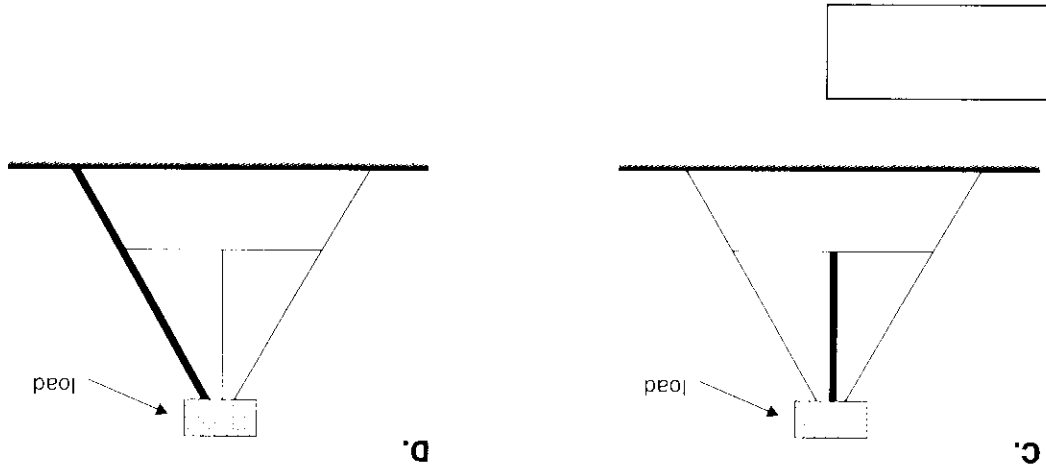
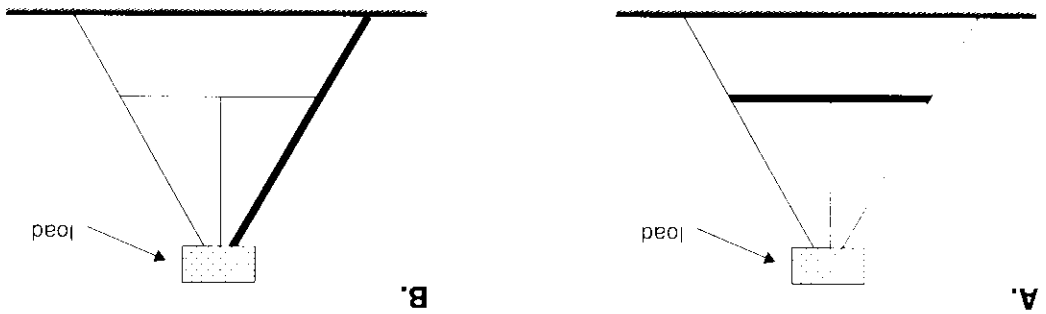
For a structure to be **stable** it must have:

- A zero net force.
- B zero torque.
- C zero torque and zero net force.
- D a high degree of friction between the earth and the base.
- E a height less than the width.

[2 marks]

Question 2

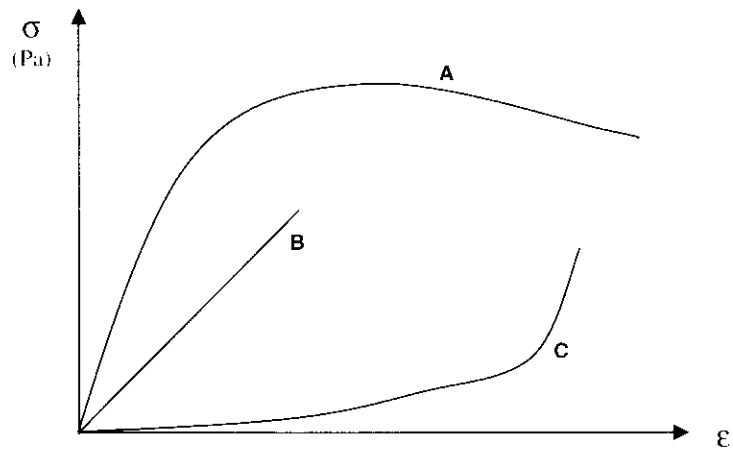
In which of the following structures is the rigid structural element, marked by the **bold** line, under tension?



[2 marks]

Question 3

The stress-strain graphs for three materials (glass, rubber and steel) are shown below.



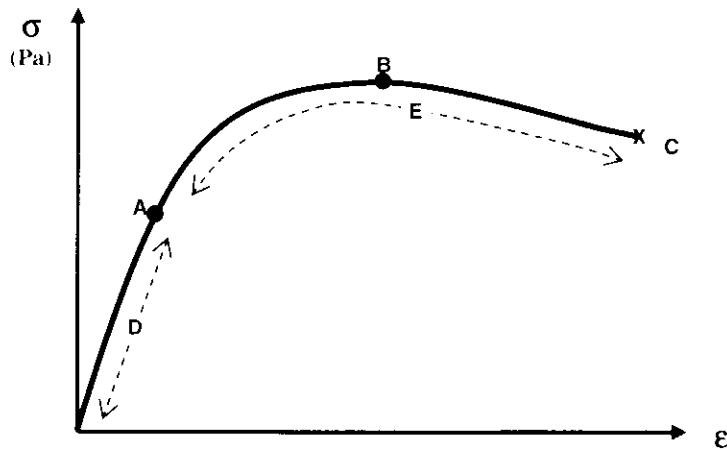
Complete the following table by indicating which graph corresponds to which material.

Material	Rubber	Steel	Glass
Graph			

[3 marks]

Questions 4 to 6 relate to the following information.

A typical stress-strain graph is given below



Question 4

Complete the following table by indicating which point (A, B or C) or region (D or E) on the graph corresponds to each of the labels in the table below.

Description	Elastic region	Ductile failure	Plastic region	Maximum stress	Elastic limit
Point or Region (A – E)					

[5 marks]

Question 5

This material is considered to be ductile. Explain what features of the graph indicate this fact.

[2 marks]

Question 6

Explain what happens to a ductile and a brittle material when placed under tension.

Ductile

Brittle

[4 marks]

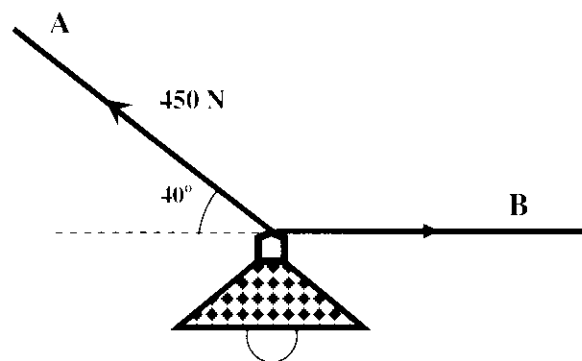
Questions 7 to 9 relate to the following information.

A heavy cast iron light fitting is suspended by two copper cables A and B, as shown in the diagram on the right.

The Young's modulus for copper:

$$Y_{Cu} = 1.25 \times 10^{11} \text{ N m}^{-2}$$

The copper wires have a diameter of 3.00 mm.



Question 7

Use the information in the diagram to calculate the mass of the light fitting.

kg

[2 marks]

Question 8

Calculate the stress in cable A.

N m⁻²

[2 marks]

Question 9

What is the change in length of cable A if its original length was 1.00 m?

m

[3 marks]