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PHYSICS

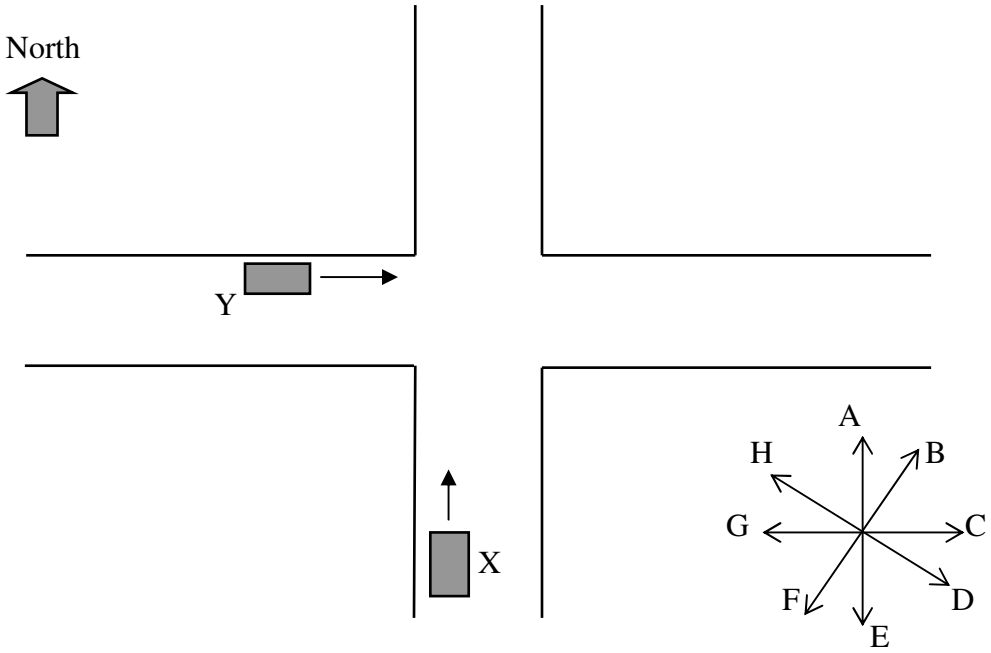
2008

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



Car X travelling to the north and car Y travelling to the east cross the intersection safely at constant speeds. Tom is a passenger in car X.

Question 1 Which one of the arrows (A – H) is the best indication of the direction of motion of car Y observed by Tom in car X at the moment shown in the above diagram? 2 marks

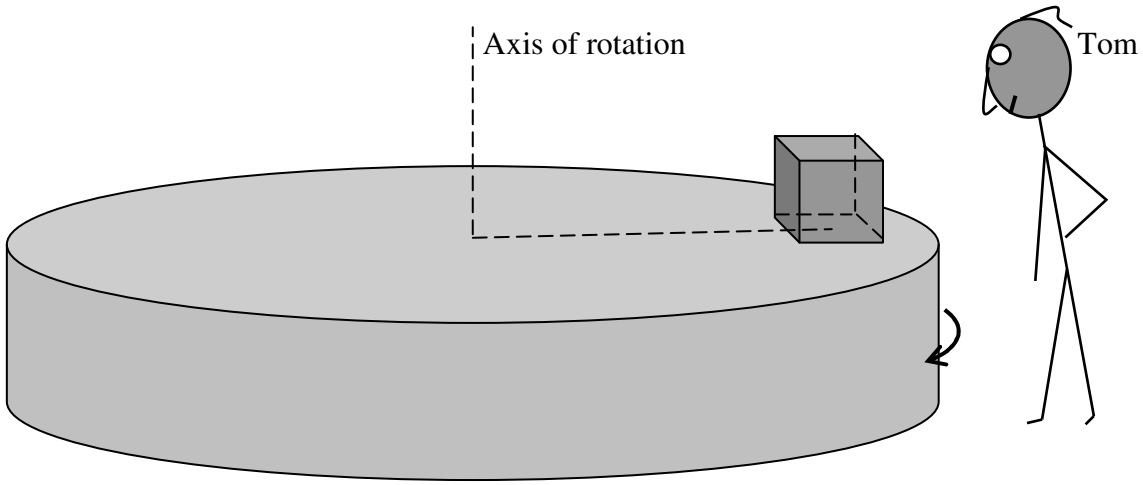
Question 2 The speeds of car X and car Y are 35 kmh^{-1} and 42 kmh^{-1} respectively. Find the speed of car Y relative to car X.

2 marks

kmh^{-1}

Question 3 Which one of the arrows (A – H) is the best indication of the direction of motion of car Y observed by Tom in car X after both cars have crossed the intersection? 2 marks

A 12-kg parcel is placed on a horizontal rotating platform 2.5 m from the axis of rotation. The coefficient of friction between the parcel and platform surface is 0.20. The platform rotates with **increasing** speed and the parcel is at rest relative to the platform.



Question 4 On the above diagram draw an arrow to show the direction of the net force on the parcel.

2 marks

Question 5 The rotating platform is a **non-inertial frame of reference**. Briefly explain the meaning of the statement.

2 marks

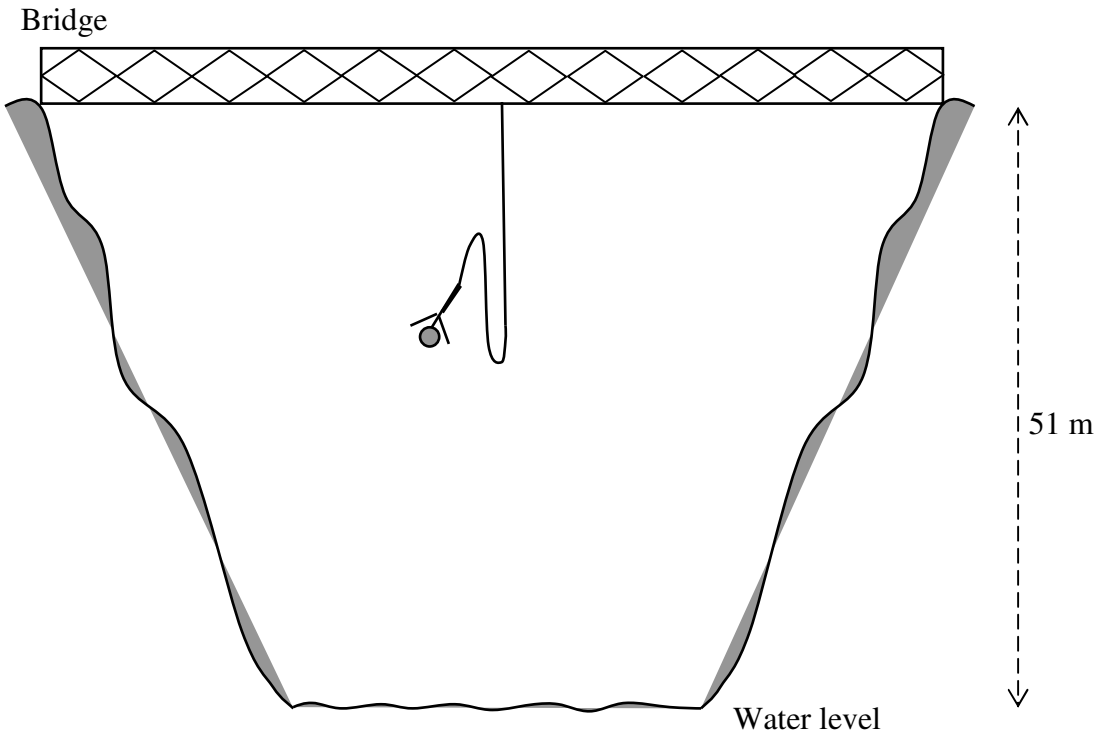
Now the speed of rotation of the platform is kept constant.

Question 6 Find the maximum speed of the parcel (observed by Tom) that allows it to rotate with the platform without sliding.

3 marks

ms^{-2}

Tom (72.0 kg) attempts a bungee jump. The jumping point is 51 m above the water. The bungee cord is 34 m long and it is elastic (i.e. it follows Hooke's law) up to an extension of 20 m. Air resistance is to be ignored. Consider Tom as a point mass starting **from rest**.



Question 7 Calculate the time that Tom is in free fall. 2 marks

s

Question 8 Determine the maximum force constant (spring constant) of the bungee cord, which allows Tom to reach the water level.

3 marks

Nm^{-1}

Question 9 The acceleration of Tom is zero at some distance **below the bridge**. Calculate that distance.

3 marks

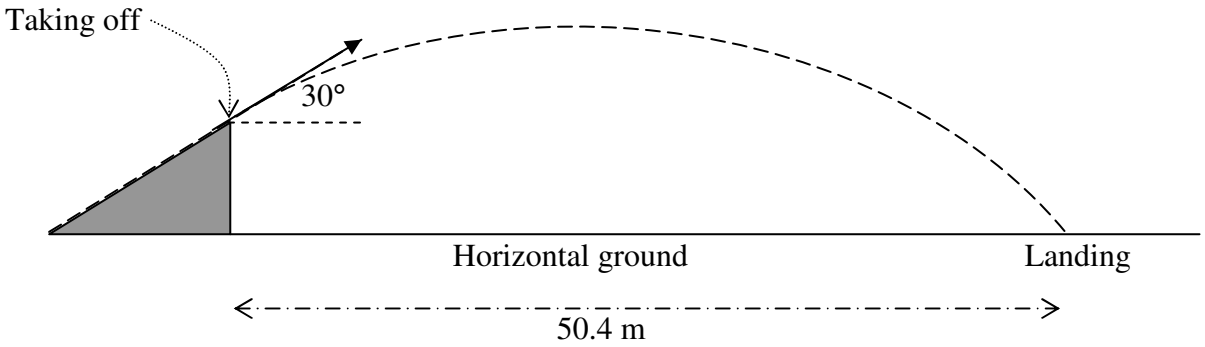
m

Question 10 Tom Junior (71.8 kg) has slightly less mass. He attempts the bungee jump using the same type and length of bungee cord. He needs to leap off the bridge vertically at speed V ms^{-1} in order for him to reach the water level. Calculate the value of V. Consider Tom Junior as a point mass.

3 marks

ms^{-1}

Tom rides a motorbike up a ramp. The total mass of Tom and the motorbike is 252 kg. The ramp makes a 30° angle with the horizontal ground. Tom clears a horizontal distance of 50.4 metres in 2.64 seconds after taking off from the ramp. Consider Tom and the motorbike as a point mass. Air resistance is to be ignored.



Question 11 Find the speed of Tom at the highest point. 2 marks

ms^{-1}

Question 12 Find the magnitude of the acceleration of Tom at the highest point. 2 marks

ms^{-2}

Question 13 Find the change in momentum (magnitude and direction) of Tom and the motorbike from the moment of taking off to the moment just before landing.

3 marks

ms^{-1}	

Question 14 Briefly explain how the law of conservation of momentum can be applied to Tom and the motorbike moving through the air during the stunt.

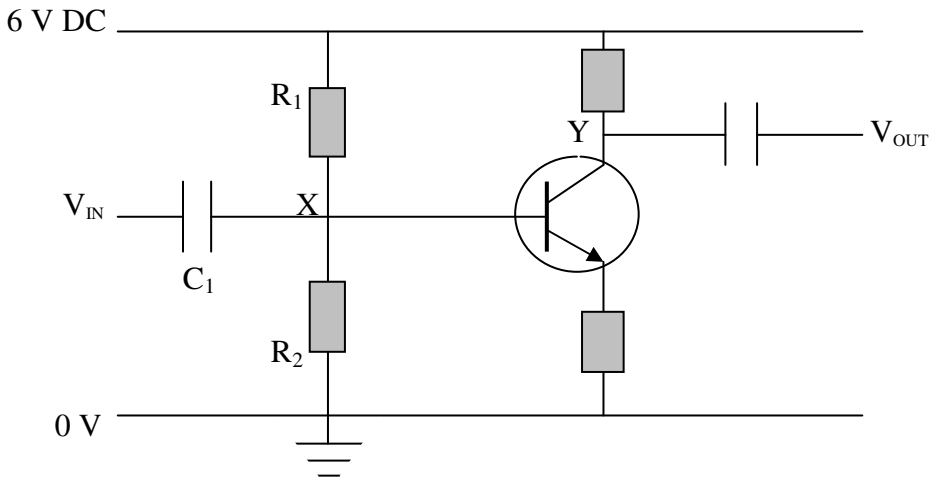
2 marks

Question 15 Find the height of the ramp. 3 marks

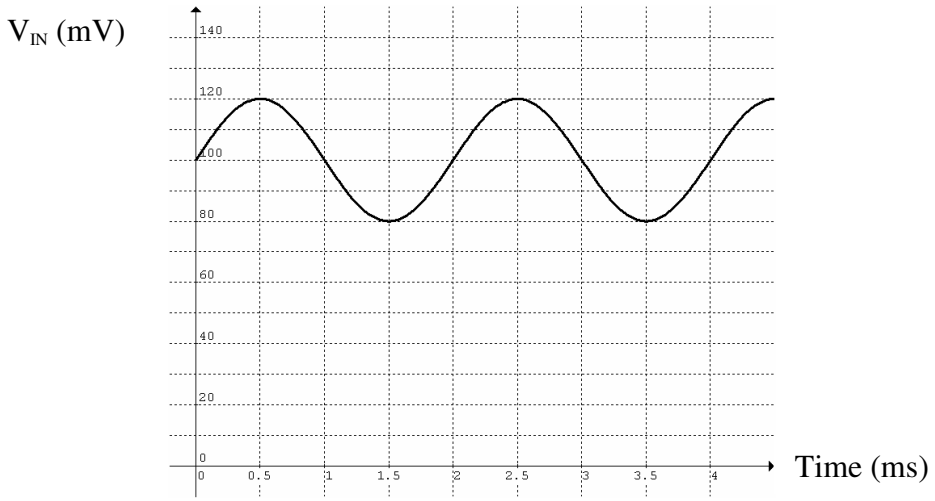
m

Area of study 2 – Electronics and photonics

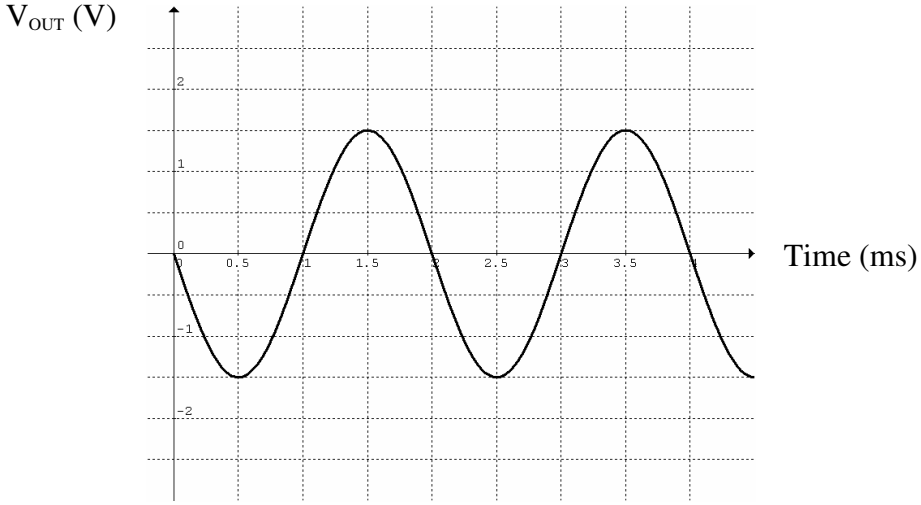
The circuit diagram for an npn transistor amplifier is shown in the following diagram. The **current gain** of the transistor is 100.



With no input signal, the voltage (potential) at point X is 1.0 V, and at point Y it is 3.0 V.
Now the signal shown below is applied at V_{IN}.



The output signal at V_{OUT} is shown below.



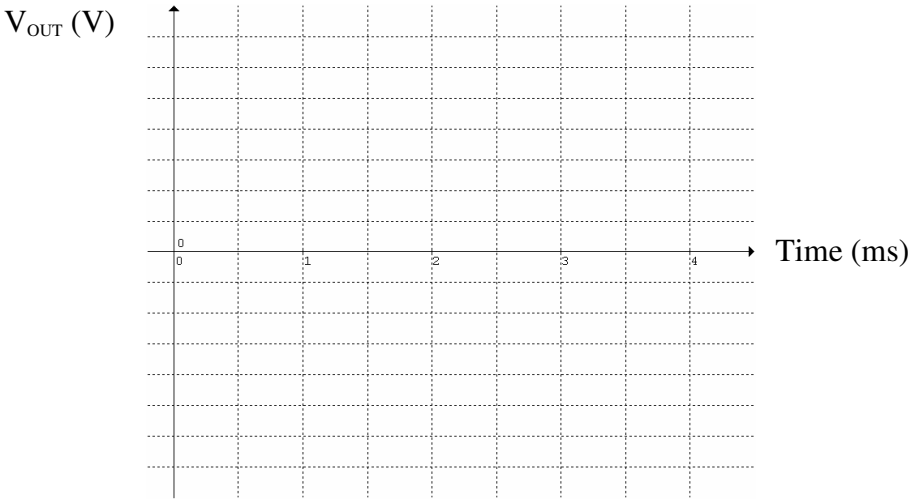
Question 1 What is the **signed** voltage gain of the amplifier? 2 marks

Question 2 What is the collector current when the base current is 8.0 μA? 2 marks

mA

Capacitor C_1 is damaged accidentally, so the original signal is now applied at point X directly.

Question 3 On the set of axes shown below sketch the output signal you would see. 2 marks



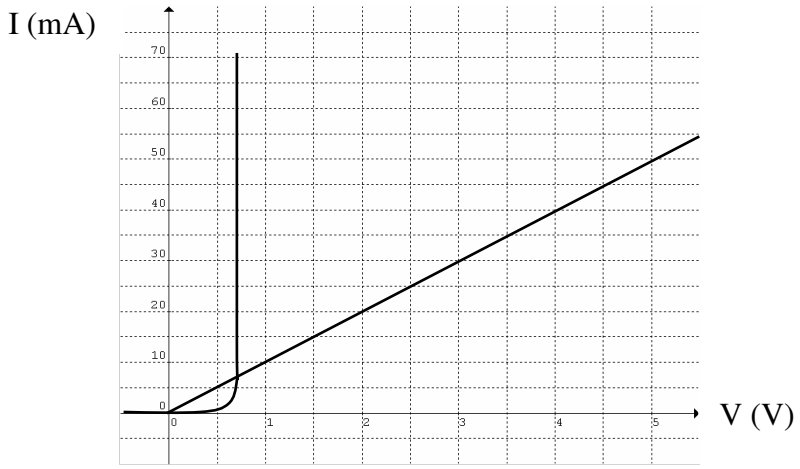
Question 4 Which one of the following terms is best to explain your answer to **question 3**? 2 marks

A. Clipping B. Saturation C. Cut-off D. Linear gain E. De-coupling

To centre the input signal at the linear operational region of the npn transistor, resistor R_2 is replaced by another resistor R_3.

Question 5 Find the value of the ratio $\frac{R_1}{R_3}$. 3 marks

The current-voltage characteristics of a diode and an ohmic resistor are shown together in the diagram below.



The diode and the ohmic resistor are connected in series with a voltage supply of 5.7 V DC. The switch-on voltage of the diode is 0.70 V.

Question 6 Draw a circuit diagram showing the connection of the diode, the resistor and the voltage supply, with the diode in conducting mode.

2 marks

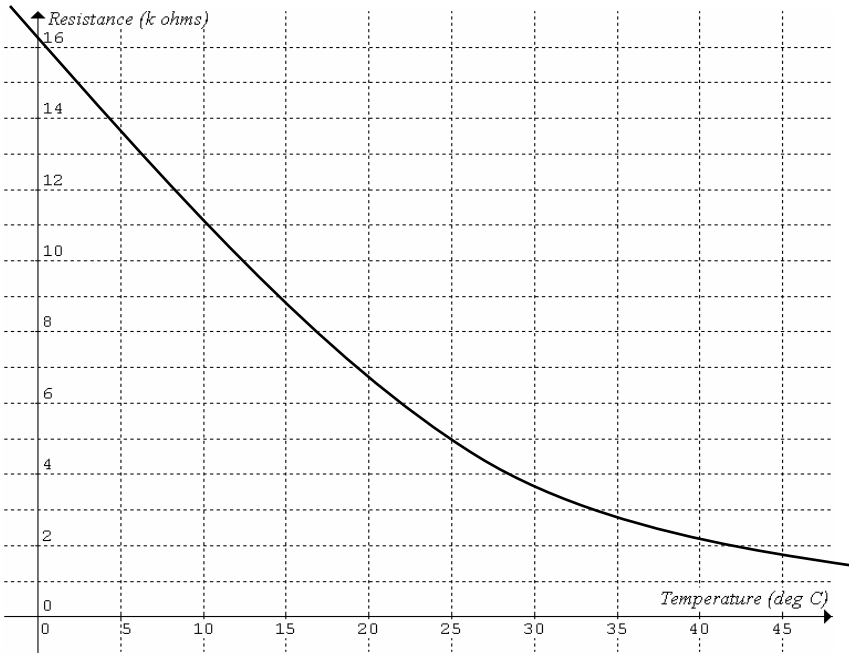
Question 7 Determine the resistance of the ohmic conductor. 2 marks

Ω

Question 8 Determine the current flowing in the diode. 2 marks

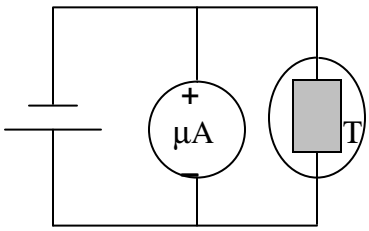
mA

Tom Junior wants to make a thermometer to measure ambient temperature using a thermistor and a microammeter. It is to be powered by a 1.5V-battery. The resistance-temperature relationship of the thermistor is shown below.

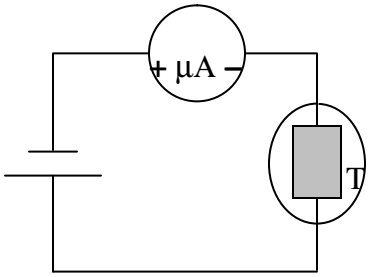


Question 9 Which one of the following circuits shows the correct wiring of the battery, thermistor and microammeter? 2 marks

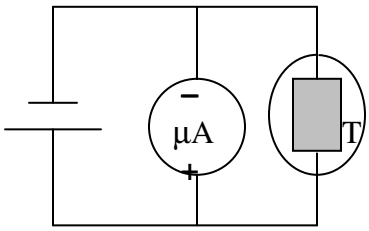
A.



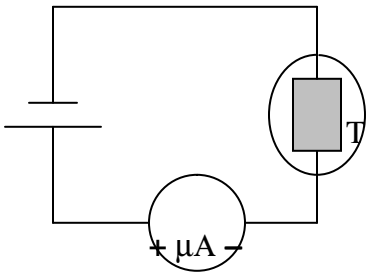
B.



C.



D.



Question 10 What is the resistance of the thermistor when the air temperature at the thermistor is 25°C? 1 mark

kΩ

Tom Junior has to recalibrate the microammeter to give readings in °C.

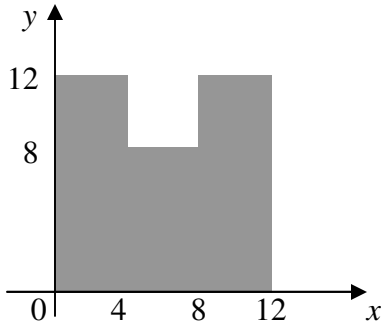
Question 11 Complete the following table. 3 marks

Current (μA)	**Temperature** (°C)
	5
300	25
660	

Question 12 Compare the accuracy of the thermometer in measuring high and low ambient temperatures when self-heating of the thermistor is taken into consideration. 2 marks

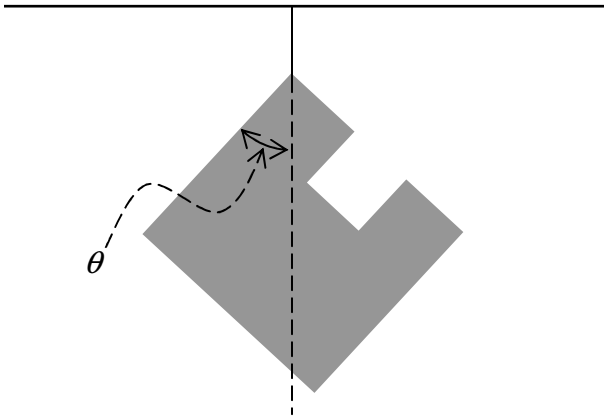
Detailed study 2 – Investigating materials and their use in structures

Tom Junior cuts a piece of cardboard into a U-shape. The measurements (cm) and coordinate axes are shown in the following diagram.



Question 1 Find the *x* and *y*-coordinates of the centre of mass of the shape. 3 marks

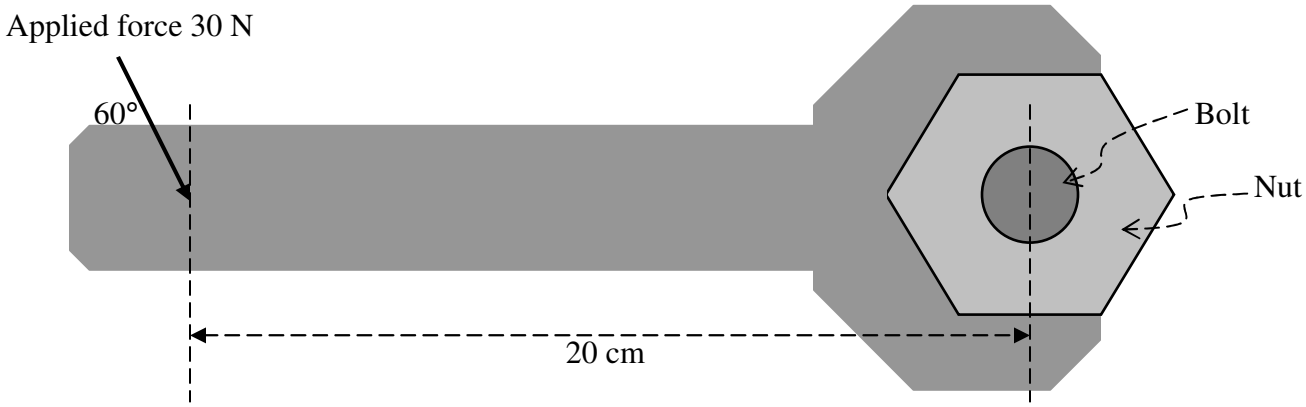
Tom Junior uses a cotton thread to hang the shape to the ceiling.



Question 2 Find angle θ in degrees (rounded to 1 decimal place) when the suspended shape is in equilibrium. 2 marks

	°

Tom uses a spanner to shift a nut from a bolt that is fixed to a wall. The nut starts to turn when he applies a force of 30 N at 60° to the handle and 20 cm from the centre of the bolt (see diagram below). The radius of the bolt is 0.80 cm



Question 3 Calculate the torque of the applied force on the nut about the axis of rotation of the nut. 3 marks

	Nm

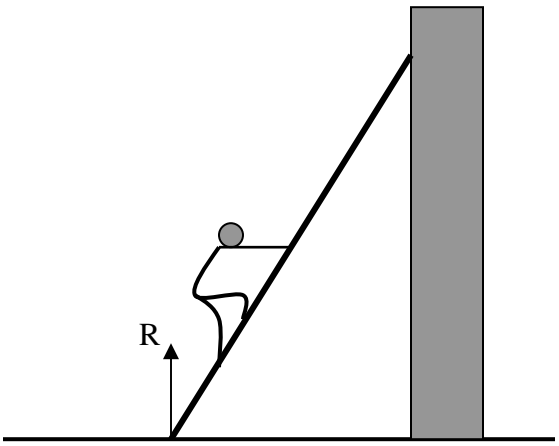
Question 4 Determine the maximum friction between the bolt and the nut. 2 marks

N

Question 5 Calculate the maximum shear stress on the bolt. 2 marks

Pa

A 28-kg ladder of uniform density along its length is placed on a rough horizontal ground and lean against a rough vertical wall.

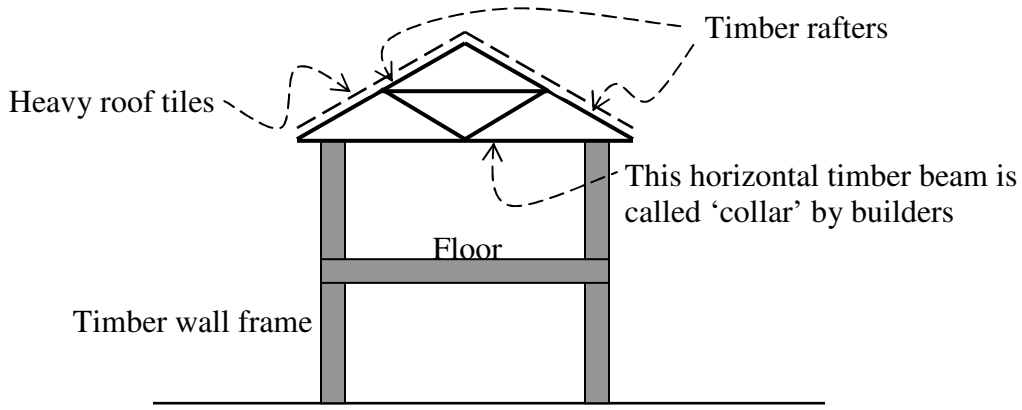


Question 6 Tom (72 kg) climbs up the ladder. Assuming the ladder is always in stable equilibrium, the **best** possible range of values (in newtons) of the normal reaction R of the ground on the foot of the ladder is

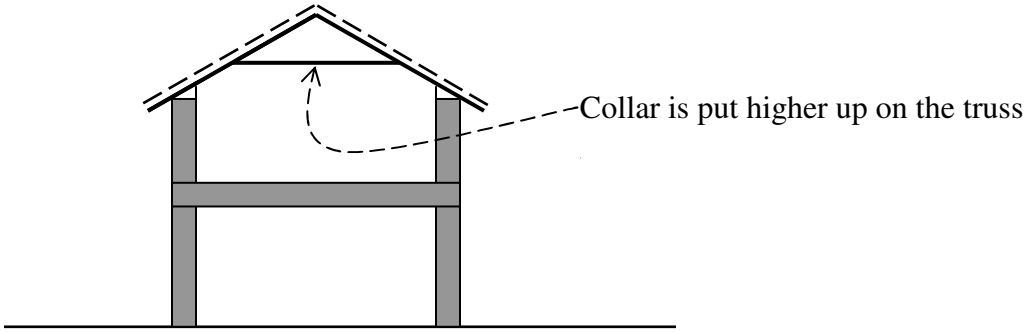
A. $200 < R < 800$ B. $0 \leq R \leq 1000$ C. $280 \leq R \leq 1000$ D. $350 < R < 950$ 2 marks

Question 7 Explain your choice of answer to question 5. 2 marks

The plan for building Tom's double-storey weatherboard house is shown below.



Tom wants to save money with an alternative plan as shown below.

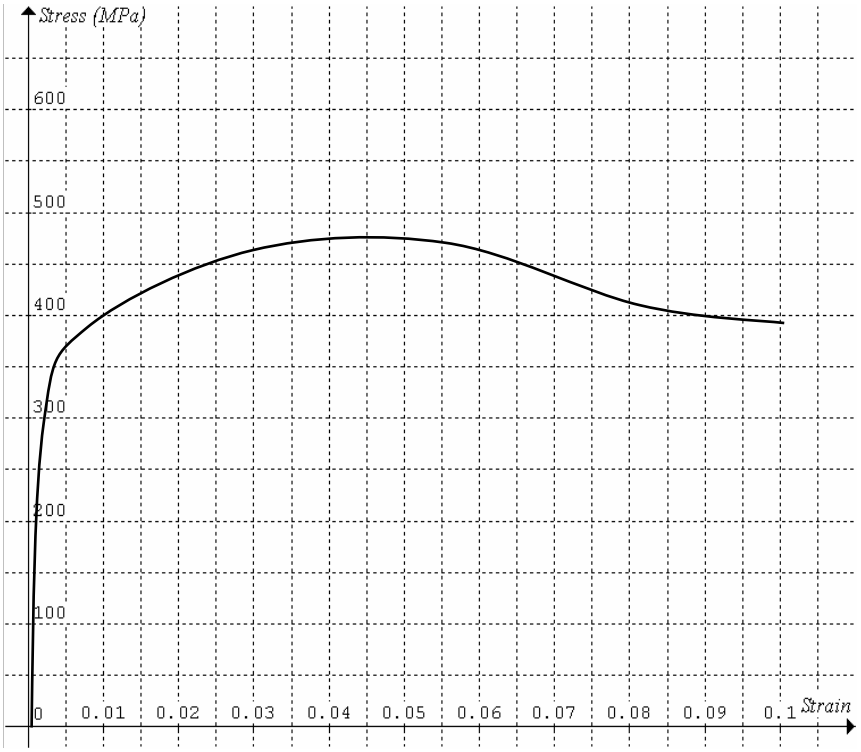


Question 8 Name two effects on the structure in raising the collars higher up. 3 marks

Question 9 Choose a different building material that can reduce these effects on the structure significantly. Give a reason for your choice.

2 marks

The tensile stress-strain graph of a new ductile material prepared by Tom and Tom Junior is shown below. It fractures when $\varepsilon = 0.1$.



Question 10 What is the stress required in breaking the material? 1 mark

MPa

Question 11 Estimate the amount of energy absorbed by each cubic centimetre of the material before it breaks.

3 marks

J

End of Trial Exam 1

