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PHYSICS

2011

Trial Examination 1

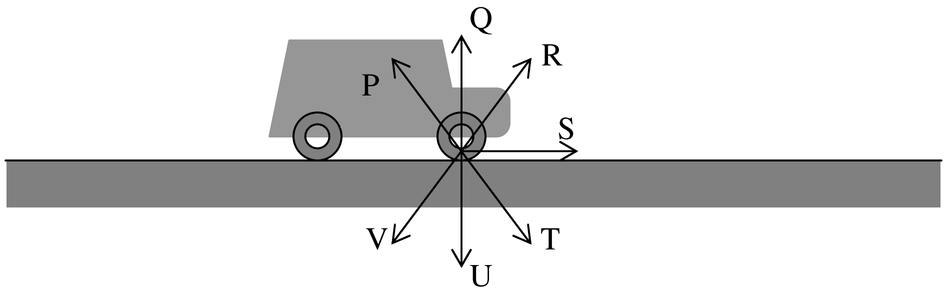
Motion in one and two dimensions
Electronics and photonics
Materials and their use in structures

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

Area of study 1 – Motion in one and two dimensions

Use the following information to answer Questions 1, 2 and 3.

A 1.2-tonne four wheel drive car speeds up uniformly from rest to 108 km h^{-1} in 10 seconds on a horizontal road. There is a constant resistive force of 200 N against the car's motion.



Question 1 Calculate the acceleration of the car.

m s^{-2}

2 marks

Question 2 Calculate the force (total) of friction between the road and the tyres.

N

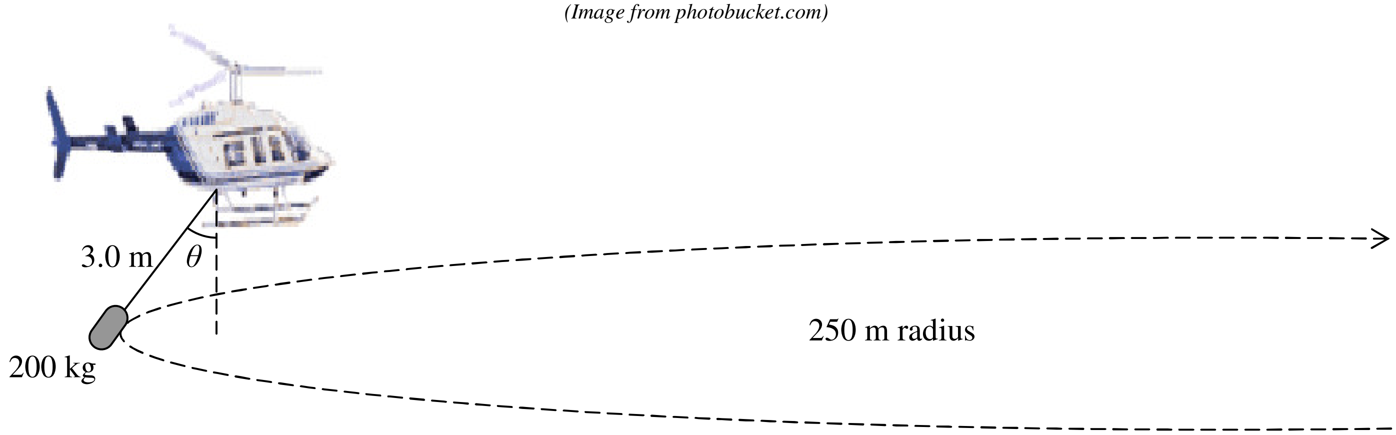
2 marks

Question 3 The direction of the reaction force of the road on the front tyre is best indicated by arrow (P, Q, R, S, T, U or V) shown in the diagram above.

2 marks

Use the following information to answer Questions 4, 5, 6 and 7

(Image from photobucket.com)



A helicopter carrying a 200-kg parcel at the end of a 3.0-m long cable flies in a horizontal circular path. It completes a full circle at a constant speed in 78.5 seconds. The radius of the path *of the parcel* is 250 m.

Question 4 Determine the magnitude of the parcel's acceleration.

$m\ s^{-2}$

2 marks

Question 5 Determine θ, the angle made by the cable with the vertical. Write your answer to the nearest degree.

3 marks

Some items fall off the parcel while the helicopter stays in its circular path.
Now the mass of the parcel becomes 100 kg.

Question 6 Determine θ, the angle made by the cable with the vertical, to the nearest degree.

1 mark

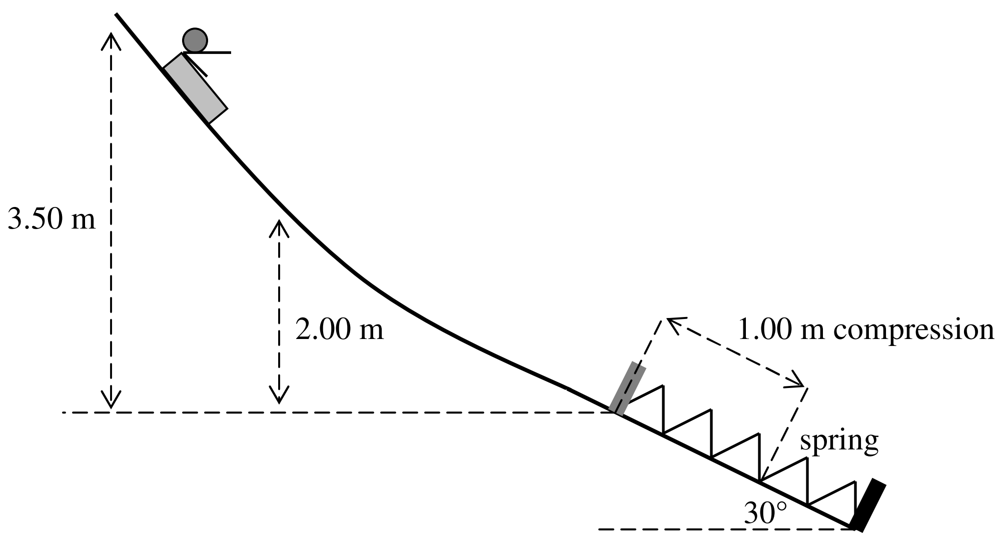
Question 7 The parcel is 300 m above the ground. Determine the time taken by each item fallen off from the parcel to hit the ground. Ignore air resistance.

s

2 marks

Use the following information to answer Questions 8, 9, 10, 11 and 12

A person in a sledge (total mass of 120 kg) slides down a frictionless icy slope from a height of 3.50 m. The sledge is initially at rest and comes to a stop momentarily after compressing a coil spring of negligible mass by 1.00 m. Consider the sledge as a point. Assume **elastic** collision between the sledge and the spring.



Question 8 Calculate the speed (3 significant figures) of the sledge just before it hits the spring.

$m\ s^{-1}$

2 marks

Question 9 Calculate the spring constant of the spring.

N m^{-1}

2 marks

Question 10 Calculate the compression (3 significant figures) of the spring when the acceleration of the sledge is zero.

m

2 marks

Question 11 Calculate the maximum speed (3 significant figures) of the sledge.

m s^{-1}

2 marks

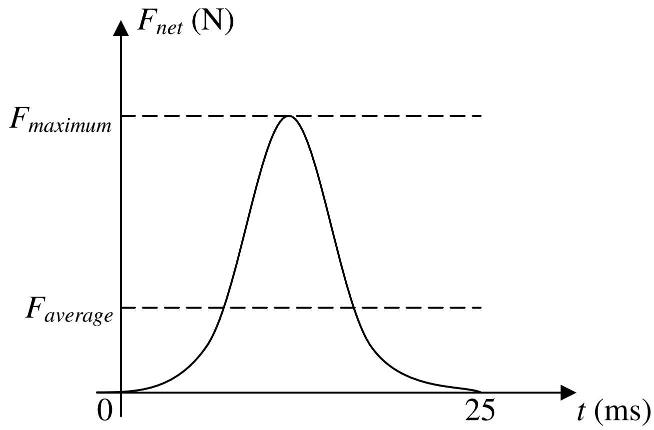
Question 12 Calculate the speed of the sledge on its rebound when it is 2.00 m (see diagram) above the spring.

m s^{-1}

2 marks

Use the following information to answer Questions 13, 14 and 15

A tennis ball (58 grams) dropped from a height of 2.5 m onto a horizontal concrete floor has a bounce height of 1.5 m. The following graph shows the net force on the tennis ball when it is in contact with the concrete floor. The tennis ball is in contact with the floor for 25 ms.



Question 13 Calculate the magnitude of the impulse acting on the tennis ball in the interval when it is in contact with the concrete floor.

N s

3 marks

Question 14 Calculate the magnitude of the average net force $F_{average}$ on the tennis ball.

N

2 marks

Question 15 Estimate the magnitude of the maximum net force $F_{maximum}$ on the tennis ball.

N

1 mark

Use the following information to answer Questions 16 and 17

A puck moving at 2.0 m s^{-1} on an air hockey table collides with a stationary identical puck head-on. The motions of the two pucks are in the same line. Let the velocities of the pucks after the collision be v_A m s^{-1} and v_B m s^{-1}. The total kinetic energy of the pucks is **halved** after the collision.

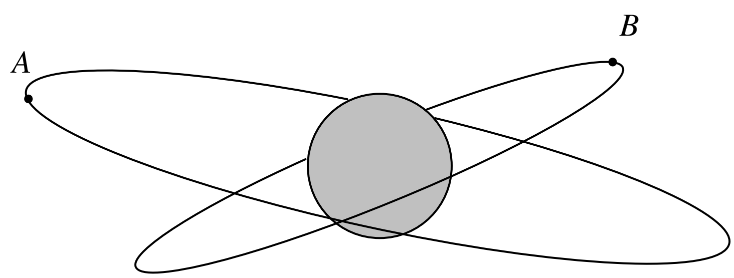
Question 16 Use energy and momentum considerations to write two simultaneous equations for v_A and v_B.

3 marks

Question 17 Show that $v_a = v_b = 1.0$.

1 mark

Use the following information to answer Questions 18, 19 and 20



Two satellites *A* and *B* are in circular orbits around the earth. The mass of the earth is 5.98×10^{24} kg. The radius of the earth is $R_{earth} = 6.37\times10^{6}$ m. The **altitude** of Satellite *A* is $3\times R_{earth}$. The altitude of Satellite *B* is $2\times R_{earth}$. $G = 6.67\times10^{-11}$ N m^2 kg^{-2}.

Question 18 Determine the exact value of the ratio $\frac{g_B}{g_A}$, where g_A is the gravitational field strength at the orbit of Satellite *A*, and g_B is the gravitational field strength at the orbit of Satellite *B*.

2 marks

Question 19 Calculate the exact value of the ratio $\frac{T_A}{T_B}$, where T is the orbital period of the satellite.

2 marks

Question 20 If the altitude of Satellite *A* is decreased by 1.0 km, estimate the change in gravitational potential energy of each kilogram of Satellite *A*.

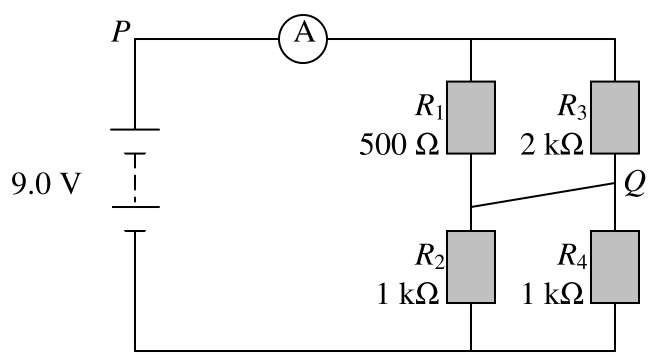
J

2 marks

Area of study 2 – Electronics and photonics

Use the following information to answer Questions 1, 2, 3 and 4

The following circuit consists of a battery supplying a constant voltage of 9.0 V, an ammeter A, and four ohmic resistors R_1, R_2, R_3 and R_4.



Question 1 What is the potential difference between point *P* and point *Q*?

V

2 marks

Question 2 Calculate the current through the ammeter.

mA

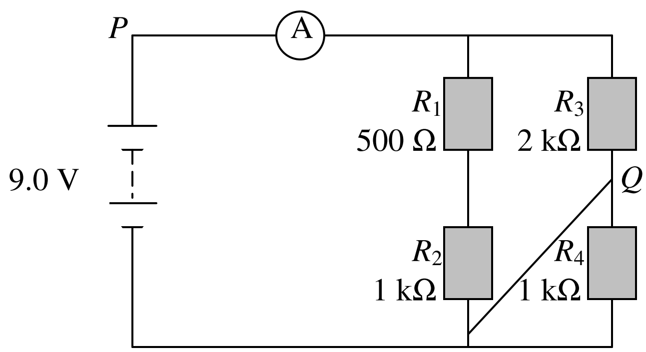
2 marks

Question 3 One of the four resistors R_1, R_2, R_3 and R_4 dissipates the most power. Calculate the power of this resistor.

W

2 marks

The circuit above is modified and the new circuit is shown below.

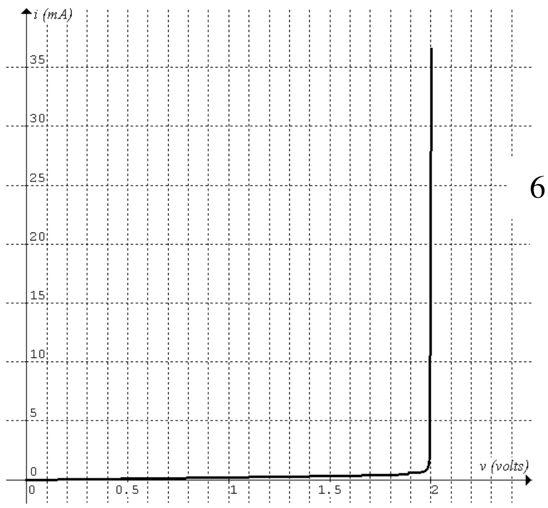


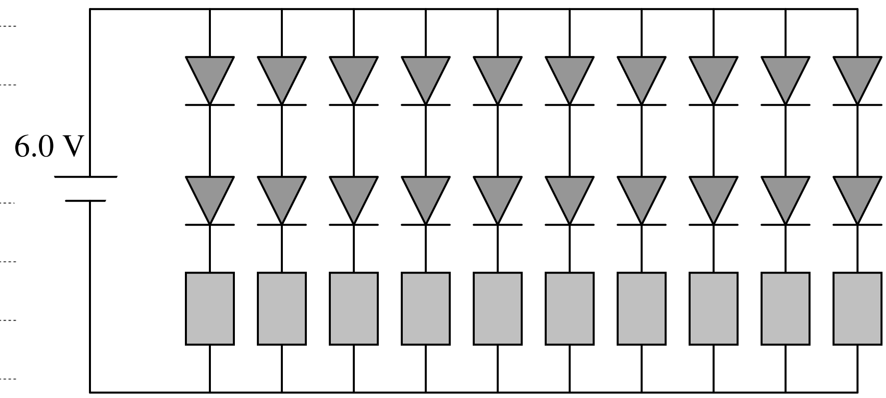
Question 4 Discuss whether the total power of the four resistors decreases, remains the same or increases. Justify your answer with calculations.

2 marks

Use the following information to answer Questions 5, 6, 7, 8 and 9

The following graph shows the *i*-*v* characteristics of a red LED. ***The LED will be damaged if the voltage across it exceeds 2.05 volts .*** The rear light of a bicycle has twenty such red LED's arranged in ten branches. Each branch has two LED's and a 100-Ω resistor connected in series. The circuit is powered by a battery providing a constant voltage of 6.0 V. The circuit is shown below.





Question 5 Determine the current through each LED.

mA

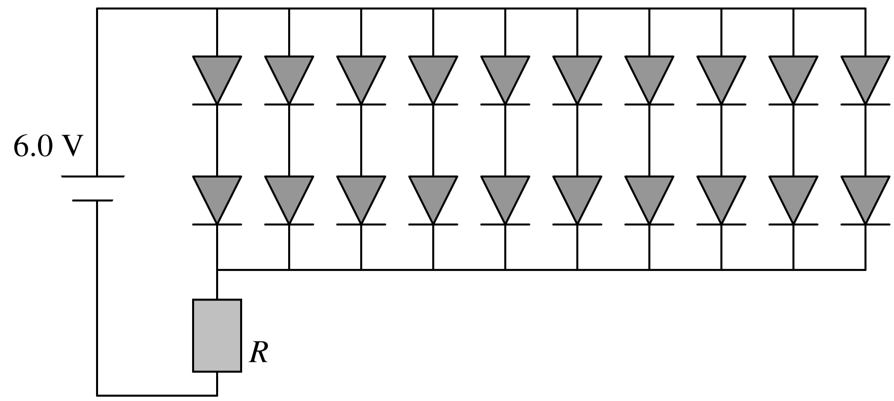
2 marks

Question 6 Determine the current through the battery.

mA

2 marks

Now the ten 100-Ω resistors are replaced with a single resistor *R* as shown in the diagram below.



Question 7 If *R* is one of the 100-Ω resistors, describe and explain the effect of the change on the output of the LEDs.

2 marks

Question 8 Determine the value of *R* required to maintain the same output of the LED's as in the original circuit.

2 marks

Question 9 What is one serious disadvantage of using a single resistor (value of *R* calculated in Question 8) in the new circuit? Support your answer with calculations.

2 marks

Use the following information to answer Questions 10 and 11

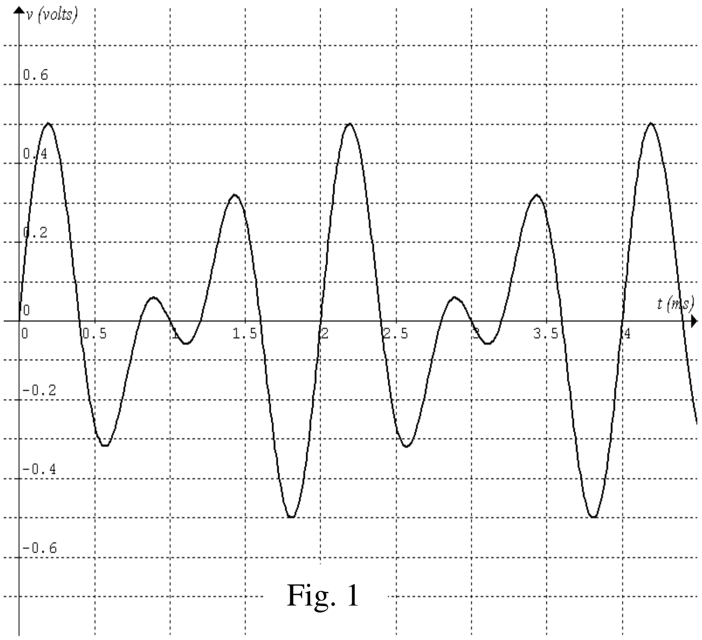


Fig. 1

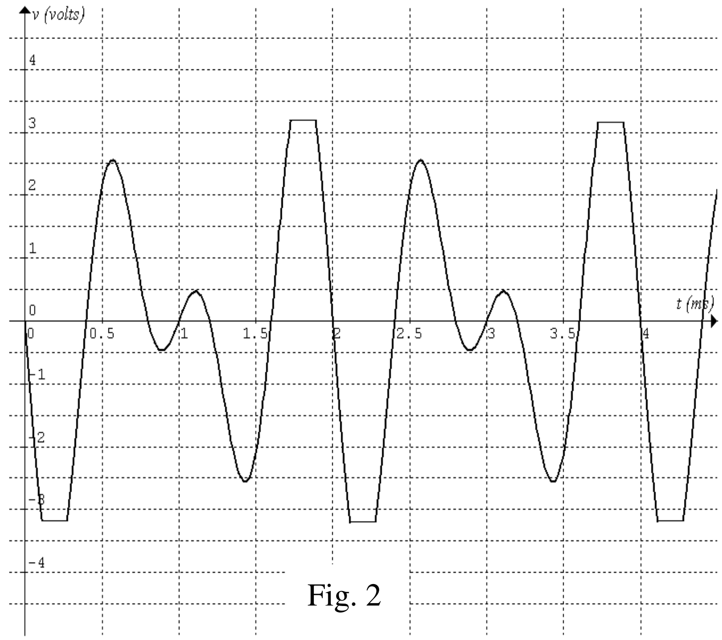


Fig. 2

Fig. 1 shows the **input** signal to a voltage amplifier. Fig. 2 shows the corresponding **output** signal of the amplifier.

Question 10 Determine the signed voltage gain of the voltage amplifier.

2 marks

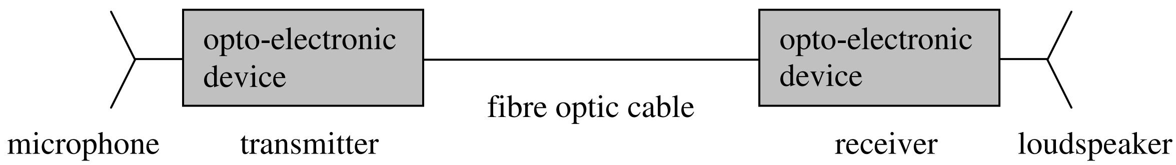
Question 11 Determine the maximum amplitude of the input signal (1 significant figure) before clipping sets in.

volts

2 marks

Use the following information to answer Questions 12 and 13

The following schematic diagram shows an analog communication system using light intensity modulation and demodulation.



Question 12 Select the **most suitable** device from the list: LDR, photodiode, LED, phototransistor, thermistor, laser diode for

(i) the transmitter [ ] and (ii) for the receiver [ ] . 2 marks

Question 13 When information is transmitted through the fibre optic cable, which one of the following statements gives the **best** description of the signal inside the cable?

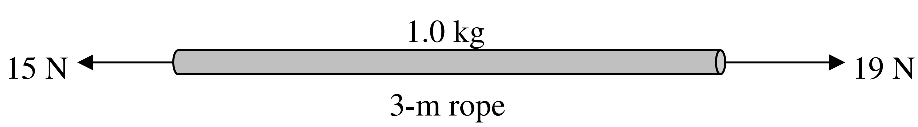
A. The signal has a constant intensity but a changing frequency.
B. The signal has a constant amplitude and a constant frequency.
C. The signal has a changing amplitude but a constant frequency.
D. The signal has a changing intensity and a changing frequency.

2 marks

Detailed study 2 – Materials and their use in structures

Multiple-choice questions: Choose the **best** answer for each question. Write the letter of your choice in each answer box.

Question 1 Two forces of 15 N and 19 N are pulling a 3-m rope at its ends. The mass of the rope is 1.0 kg.



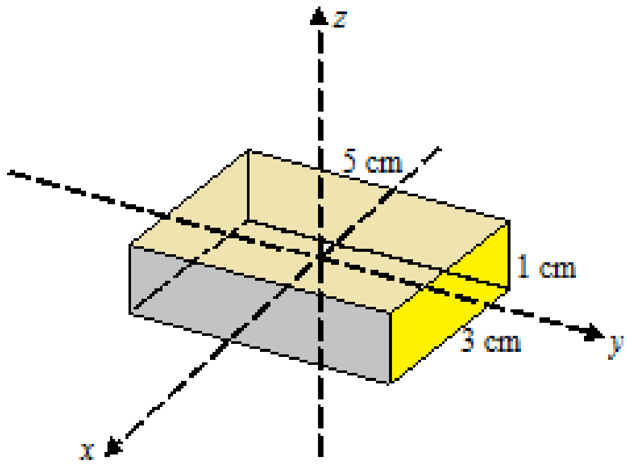
The tension in the rope is

A. a constant value of 15 N
B. a constant value of 19 N
C. a constant value of 34 N
D. not a constant value

2 marks

Use the following information to answer Questions 2, 3 and 4

A rectangular piece of elastic material is shown in the following diagram. The material is compressed parallel to (i) the *x*-axis, (ii) the *y*-axis and (iii) the *z*-axis by 1 mm.



Question 2 Young's modulus *E* is

A. the highest parallel to the *x*-axis.
B. the highest parallel to the *y*-axis.
C. the highest parallel to the *z*-axis.
D. the same in all directions.

2 marks

Question 3 The force constant *k* in Hooke's law is

A. the highest parallel to the *x*-axis.
B. the highest parallel to the *y*-axis.
C. the highest parallel to the *z*-axis.
D. the same in all directions.

2 marks

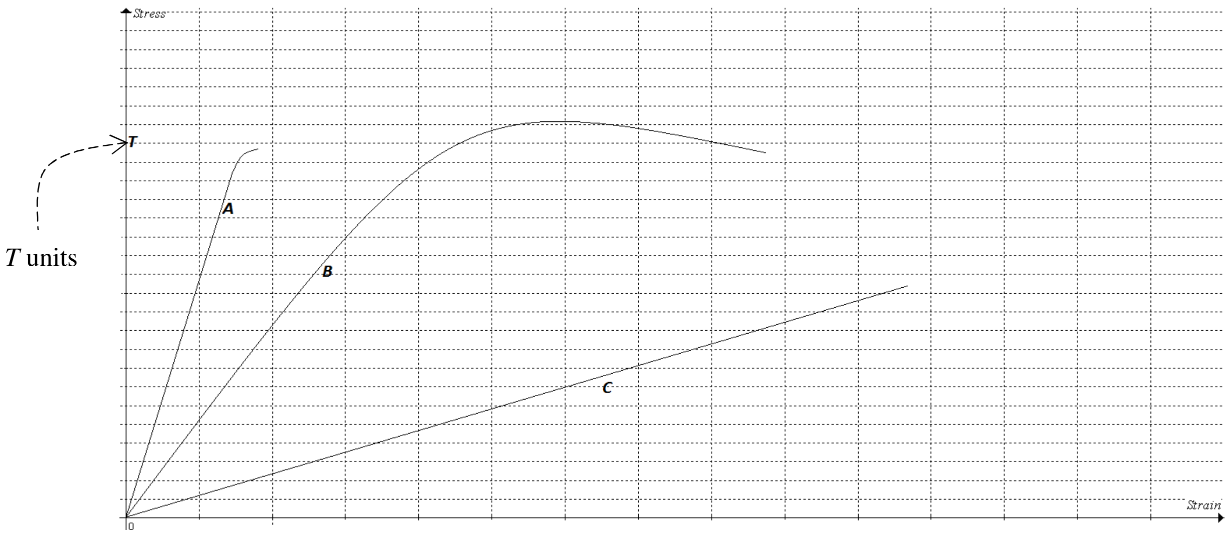
Question 4 The compressive stress required is

A. the highest parallel to the *x*-axis.
B. the highest parallel to the *y*-axis.
C. the highest parallel to the *z*-axis.
D. the same in all directions.

2 marks

Use the following information to answer Questions 5 and 6

The stress-strain graphs of materials *A*, *B* and *C* under tensile stress up to their breaking points are shown below.



Question 5 Which one of the following statements gives the best comparison of the materials?

A. Material *B* is the strongest.
B. Material *A* is the toughest.
C. Material *C* is the most ductile.
D. Only one of the three materials is brittle.

2 marks

Question 6 Which one of the following events is *possible*?

A. Material *A* breaks when a tensile stress greater than *T* units is applied to it.
B. Material *B* breaks when a tensile stress of *T* units is applied to it.
C. Material *B* breaks when a tensile stress greater than *T* units is applied to it.
D. Material *C* breaks when a tensile stress of *T* units or greater is applied to it.

2 marks

Question 7 A 2-tonne concrete column is erected upright. It has a uniform cross-section of 220 cm^2 in area. The stress at the base of the column is closest to

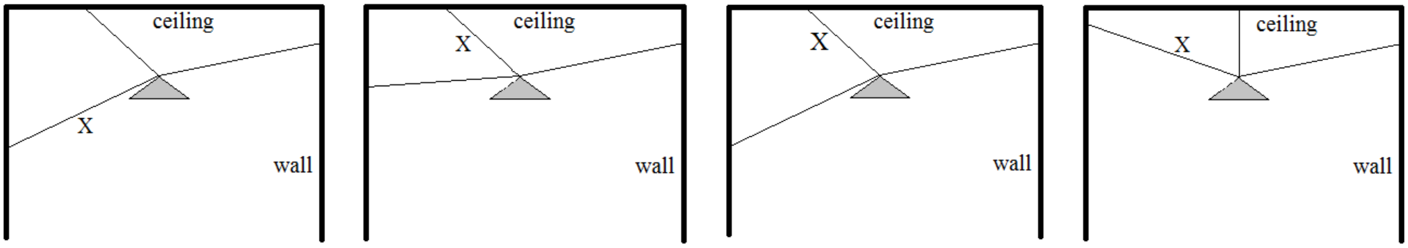
A. 100 MPa
B. 10 MPa
C. 1 MPa
D. 100 kPa

2 marks

Question 8 A lamp is held in position by three strong cords. The cords are in the same vertical plane. Assume that each cord is strong enough to support the lamp without extension. One of them is labeled as X.

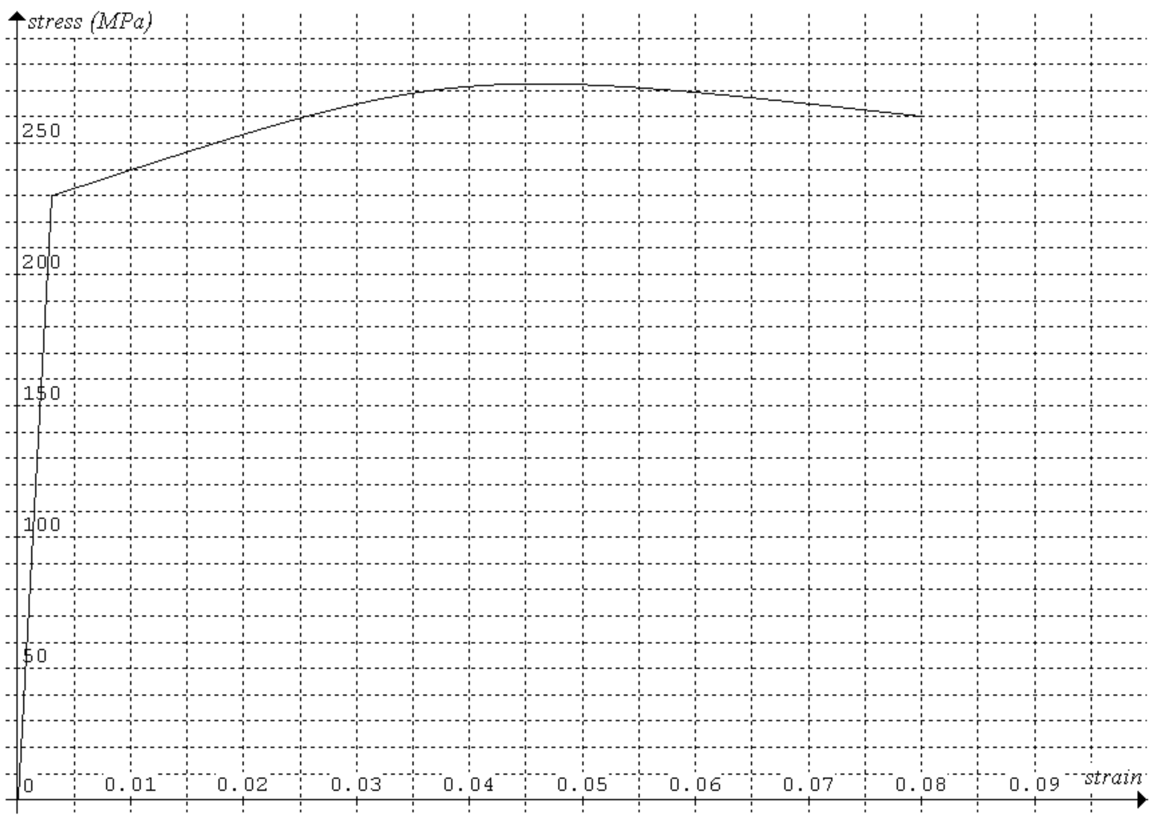
Which one of the following situations requires cord X to keep the lamp at the position shown?

A. B. C. D.



2 marks

Question 9 The stress-strain graph for aluminium is shown below.

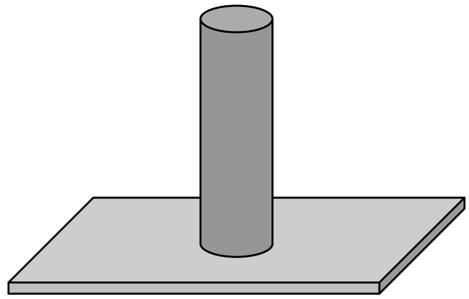


The estimated **maximum elastic strain energy** in MJ m^{-3} for aluminium is closest to

A. 4×10^{-7}
B. 0.3
C. 1
D. 20

2 marks

Question 10 A cylindrical column has a uniform density. It has a radius of 20 cm and a height of 2.5 m. It stands vertically on solid ground.

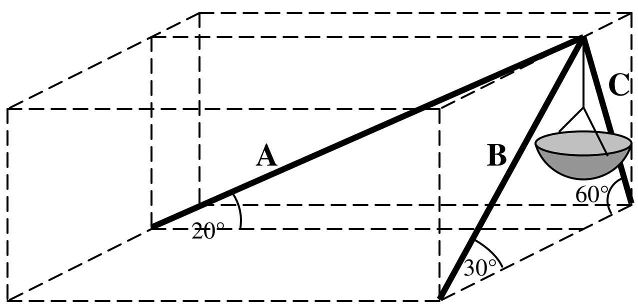


The maximum angle of lean before it topples over is closest to

A. 2° B. 5° C. 10° D. 15°

2 marks

Use the following information to answer Questions 11 and 12



Rods **B** and **C** support a 10-kg pot of soup. Rod **A** prevents **B** and **C** from toppling over. **A**, **B** and **C** are rigid and have negligible mass. The rough ground provides enough friction to stop **B** and **C** from slipping. The angles made by **A**, **B** and **C** with the ground are 20°, 30° and 60° respectively.

Question 11 The compression in rod **B** is closest to

A. 50 N
B. 40 N
C. 30 N
D. 20 N

2 marks

Question 12 Which one of the following statements is **false**?

A. The net force on **A** is zero and the net torque on **A** is also zero.
B. The sum of the compressions in **B** and **C** is less than the weight of the pot of soup.
C. Rod **A** is always in compression.
D. The pot of soup is in unstable equilibrium if **A** is not pegged to the ground.

2 marks

End of Trial Exam 1