Focus study group

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PHYSICS

Written examination 1

2011

QUESTION AND ANSWER BOOK

Section	*Number of questions*	*Number of questions To be answered*	*Number of marks*
A – Core – Areas of study			
1. Motion in one and two dimensions	17	17	40
2. Electronics and photonics	13	13	26
B – Detailed studies			
1. Einstein's special relativity **OR**	12	12	24
2. Materials and their uses in structures **OR**	12	12	24
3. Further electronics	12	12	24
			Total 90

- Students are permitted to bring into the examination room: pens, pencils, highlighters, erasers, sharpeners, rulers, up to two pages (one A-4 sheet) of prewritten notes (typed or handwritten) and 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. The question and answer book has a removable data sheet.
- Answer sheet for Section B multiple-choice questions

Instructions

- Remove data sheet during reading time.
- Write your **name** on this question and answer book and the answer sheet for Section B multiple choice questions.
- Unless otherwise indicated, diagrams in this book are **not** to scale.

At the end of the examination

- Place the answer sheet for Section B multiple choice answers inside the front cover of this book.

Students are NOT permitted to bring mobile phones and/or any other unauthorised electronic devices into the examination room.

Instructions for Section A

Answer **all** questions for **both** Areas of study in this section in the spaces provided.
Where an answer box has a unit printed in it, give your answer in that unit
You should take the value of g to be 10 m s^{-2}.
In questions where more than one mark is available, appropriate working should be shown.

Area of study 1 – Motion in one and two dimensions

Fig. 1

A 70 kg sky diver descends with a constant speed of 10ms^{-1}. The mass of the parachute is 10 kg. There is negligible air resistance acting on the person.

Question 1
What is the total upward force acting on the parachute?

N

2 marks

Question 2
What is the total tension acting in the parachute ropes? (Assume that all of the tension is vertical.)

N

2 marks

Question3
When the sky diver is 20 m above the surface of a body of water, the parachute is unclipped so that the sky diver free falls into the water. With what speed does the sky diver hit the surface of the water?

m s^{-1}

2 marks

Figure 2 shows the path taken by a stunt plane during a "loop the loop". At the bottom of the loop, the plane has a speed of 56 m s^{-1}. The pilot has been instructed to ensure that the acceleration of the plane should be kept below 5g (i.e. 5 times the acceleration due to gravity) to avoid "blacking out".

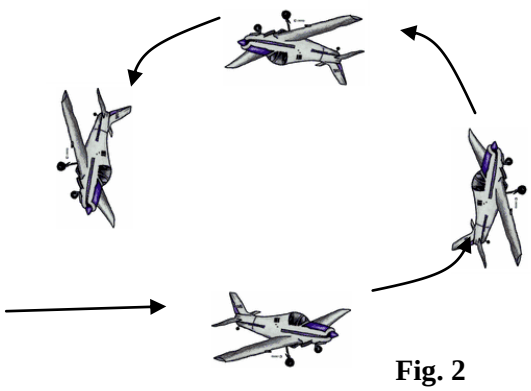


Fig. 2

Question 4

Determine the smallest radius of the loop so that the pilot does not "blackout" at the lowest point.

m

2 marks

Question 5

Assuming the loop is performed at constant speed, which of the arrows in Figure 2a shows the direction of the net force acting on the pilot when the plane is at the lowest point of the loop.

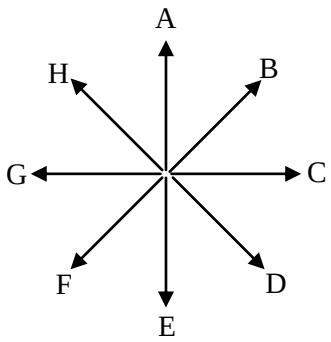


Fig. 2a

2 marks

Question 6

Suppose that the plane could complete the loop at constant speed. Explain why the pilot is likely to feel heavier when the plane is at the lowest point of the loop compared with when it is at the top of the loop.

3 marks

A ball serving machine accelerates tennis balls from rest to a speed of 144 km h^{-1} (i.e. 40 m s^{-1}) so that tennis players can practice returning fast serves. The machine uses compressed air to apply a constant force to tennis balls as they travel along the barrel of the machine. The length of the barrel is 0.60 m. The mass of each tennis ball is 57 gm (i.e. 0.057 kg).

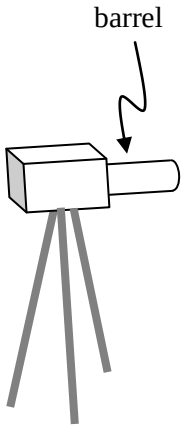


Fig. 3

Question 7

Determine the acceleration of the ball as it travels along the barrel of the machine

	m s^{-2}

2 marks

Question 8

What is the magnitude of the net force acting on the tennis ball as it travels along the barrel?

	N

2 marks

Question 9

To simulate a realistic serve, the ball must travel a horizontal distance of 30m before hitting the ground. If the ball was launched horizontally with a speed of 40 ms^{-1}, from what height above the ground should the ball be launched from the machine?

	m

4 marks

Two students, Ky and Lee have been learning about the transfer of momentum from one body to another. Ky says that if everyone in Australia jumped off a two metre ladder and hit the ground at exactly the same time then people on the opposite side of the world should be able to feel a slight bump. Lee does not agree.

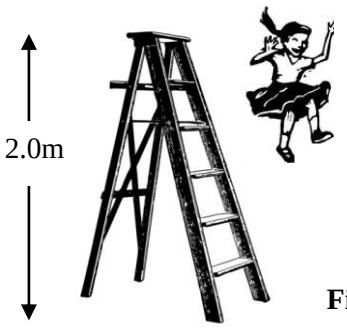


Fig. 4

Question 10

Given that the population of Australia is approximately 20 million and that the average mass of the population (including children and the elderly) is 60 kg, what momentum would the population have just before hitting the ground?

$kgms^{-1}$

2 marks

Question 11

The mass of the Earth is 5.98×10^{24} kg. Determine the combined velocity of the Australian population and the Earth immediately after landing on the ground.

ms^{-1}

3 marks

Question 12

Who is correct, Ky or Lee? Give some reasoning to support your answer.

1 mark

Ben keeps fit by riding his mountain bike. He and his bike have a total mass of 80kg. When he rides up one particular hill he has to work against friction (200 N) and weight. The length of the up-hill section is 15m which increases his elevation by 10m.

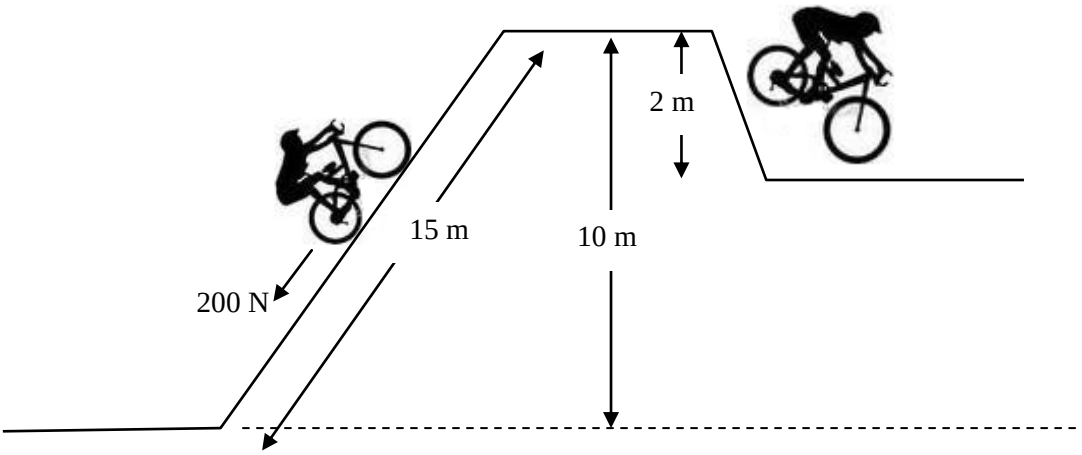


Fig. 5

Question 13
How much work in total is done by Ben in completing the up-hill section?

J

3 marks

Shortly after the up-hill section there is a near vertical "drop-off" (i.e. a section where the wheels have virtually no grip with the ground). Ben's bike has front suspension; for the sake of this question this means that the front wheel is attached to the bike via a spring mechanism that can compress to absorb energy. At the bottom of the drop-off the bike momentarily comes to rest and the spring compresses a a maximum distance of 20 cm (0.20 m).

Question 14
How much potential energy is stored in the spring when it is fully compressed?

J

2 marks

Question 15
What is the spring constant of the front suspension?

Nm^{-1}

3 marks

Question 16

A rocket-ship of mass 10M is at rest on the Earth's surface. A satellite of mass 1M is in orbit about the Earth at an altitude of 2R where R is the radius of the Earth.

They both experience gravitational force due to the Earth's gravitational field. How does the gravitational force acting on the satellite compare with the gravitational force acting on the rocket-ship?

2 marks

Question 17

Determine the speed of the satellite as it orbits the Earth. $R_E = 6.37 \times 10^6$ m, $M_E = 5.98 \times 10^{24}$ kg, $G = 6.67 \times 10^{-11}$ Nm^2kg^{-1} and the mass of the satellite = 2000 kg

ms^{-1}

3 marks

Area of study 2 – Electronics and photonics

Figure 1a below shows how the current varies with voltage for a diode. Figure 1b shows how the diode is connected into a circuit.

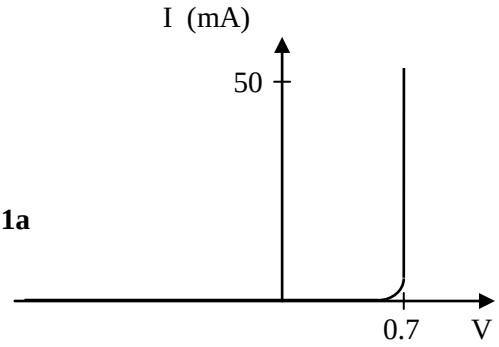


Fig. 1a

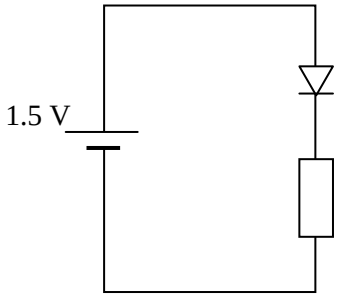


Fig. 1b

Question 1

Calculate the current flowing through the 10Ω resistor. (Working out or reasoning must be shown.)

mA

2 marks

Question 2

The circuit is modified as shown in Figure 2. Calculate the current flowing through the 10Ω resistor now. (Working out or reasoning must be shown.)

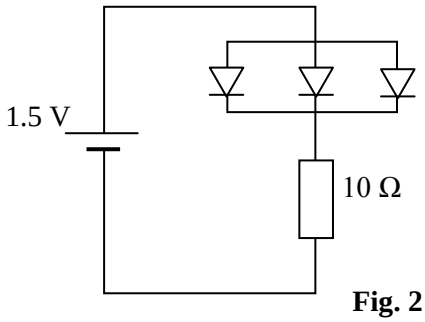


Fig. 2

2 marks

mA

Question 3

The circuit is modified again as shown in Figure 3. Calculate the current through the 10Ω resistor now. (Working out or reasoning must be shown.)

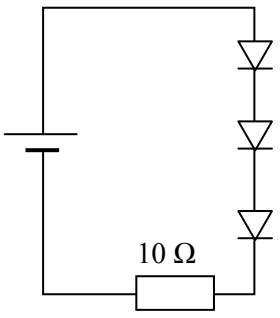


Fig. 3

mA

2 marks

Figure 4 below shows how the resistance of a thermistor varies with temperature.

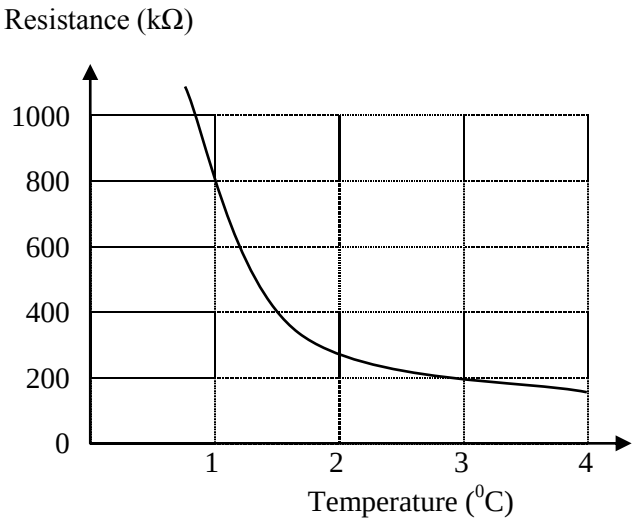


Fig. 4

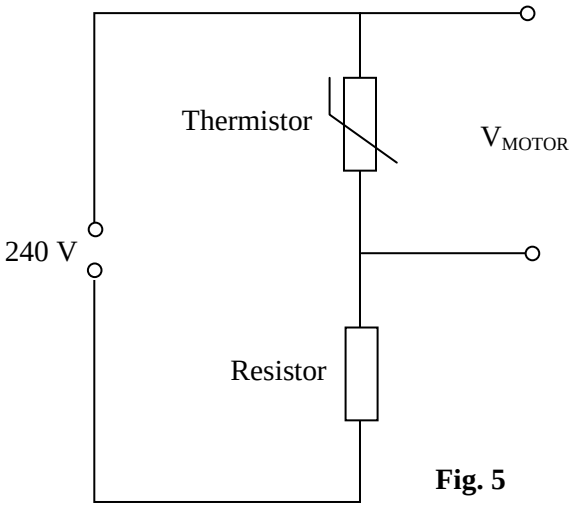


Fig. 5

Question 4

At what temperature is the resistance of the thermistor 500 kΩ?

^{0}C

1 mark

Figure 5 above shows how the thermistor is to be connected. The on/off switch for the motor is to be triggered at a temperature of 3^0C. The motor requires a voltage of 80V.

Question 5

What value of the resistor will cause the on/off switch to be triggered at 3^0C?

Ω

3 marks

Question 6

The circuit is to be used in a refrigerator. If the circuit diagram has been designed correctly the cooling motor will switch <u>on</u> when the temperature rises above 3^0C, whereas if the circuit has not been designed correctly the motor will switch <u>off</u> when the temperature rises above 3^0C.
Is the circuit correct?

1 mark

Question 7

Explain your answer to question 7 above.

3 marks

Both sound and laser light travel as waves. Optic fibres can carry signals, originating from a sound source, over long distances by converting the sound waves to electrical waves to light waves. However, before this can be done the waves need to be **modulated**.

Question 8
Using the example above, what does the term modulation mean?

3 marks

Figure 6 below shows some diagrams representing various waves.

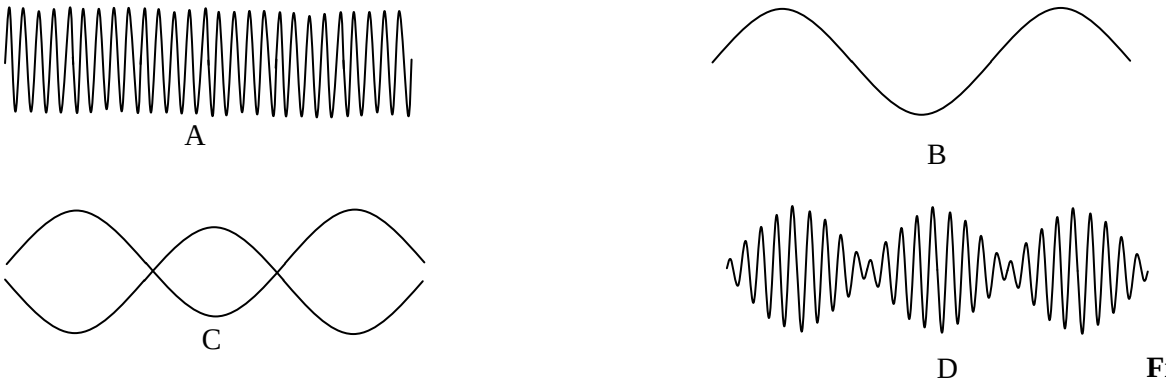


Fig. 6

Question 9
From the list (**A –D**) of waves above, the waves that would be most suitable for representing:

Sound waves

Modulated light waves

2 marks

Question 10
There are many electronic components that could be used to convert the modulated laser light back to an electronic signal. Name one.

1 mark

Figure 7 below represents the voltage characteristics for an amplifier.

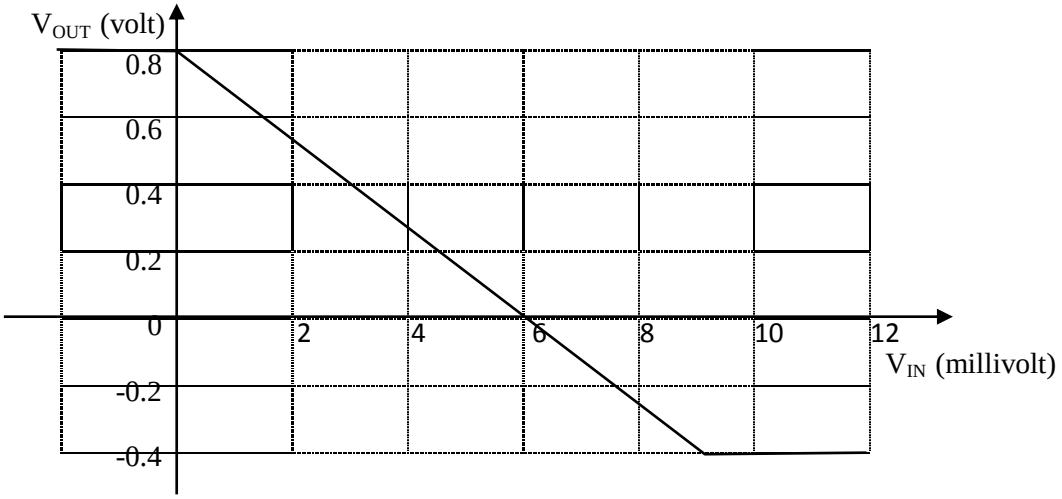


Fig. 7

Question 11

Is the amplifier an **inverting** or **non-inverting** amplifier?

1 mark

Question 12

Determine the gain of the amplifier

Gain =

2 marks

Question 13

Figure 8 below shows how the input varies with time. Use the grid to the right below to show how the output varies with time.

3 marks

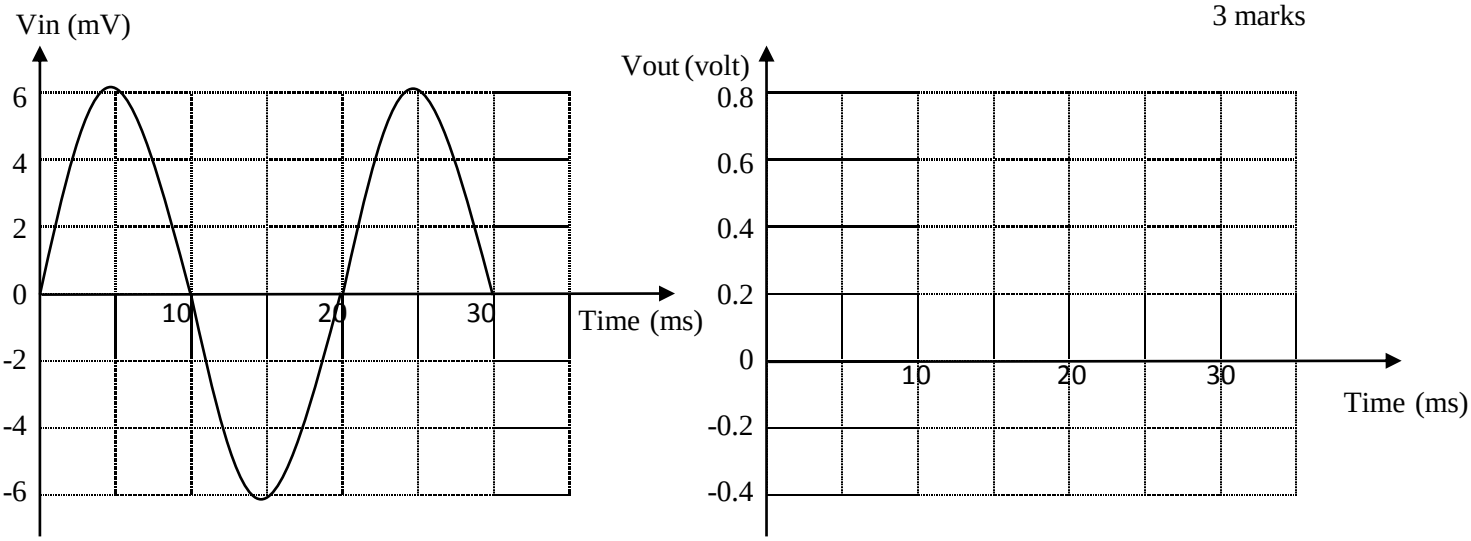


Fig. 8

Detailed study 1 – Einstein's special relativity

Question 1

Michelson and Morley performed a well documented experiment in 1887. From this experiment they concluded that:

A. The speed of light is3.0×10^8 ms^{-1}

B. Light from a receding source exhibits a "red-shift"

C. Their experiment did not support the presence of a medium known as the ether

D. Light is an electromagnetic wave

Question 2

An inertial frame of reference is:

A. a frame of reference where Newton's first law of motion is obeyed

B. an accelerating frame of reference

C. any frame of reference that is moving in a straight line

D. any frame of reference moving around a circular path such as the Earth around the Sun

Question 3

Stanley is standing on the platform of a station. He has a suitcase which he measures to be exactly 1.0m long. Leah is riding on the Lightning Express which passes though the station at a speed close to the speed of light. She has an identical suitcase to Stanley's. Which of the following statements is correct?

A. Stanley says Leah's suitcase looks to be shorter than 1.0m, so his suitcase will look a little longer than 1.0m according to Leah

B. Since Stanley is stationary, his suitcase will appear to be 1.0m long to both himself and Leah

C. Stanley measures his suitcase to be exactly 1.0m long. Leah measures her suitcase to be a little less than 1.0m

D. Both Stanley and Leah measure their own suitcases to be exactly 1.0m long.

Question 4

With reference to question 3 above, suppose the Lightning Express had a speed of *v* relative to the station. Which of the following represents the length of Stanley's suitcase in metres as measured by Leah?

A. 1.0 **B.** $\sqrt{1-\frac{v^2}{c^2}}$

C. $\frac{1}{\sqrt{1-\frac{v^2}{c^2}}}$ **D.** $1-\frac{v^2}{c^2}$

Question 5

Kim runs with speed *v* towards a stationary fire truck which is sounding its alarm. The speed of sound in air is *S*.

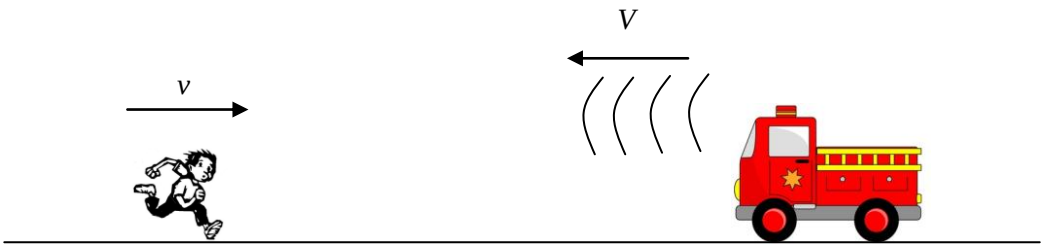


Fig. 1

Kim measures the speed of sound from the truck to be:

A. slightly less than *S*
B. equal to S
C. slightly greater than *S*
D. dependent on the frequency of the sound.

Question 6

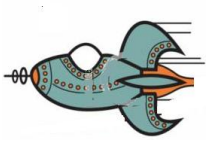


Fig. 2

Albert is riding in his spaceship at a speed close to the speed of light towards a distant star. The speed of light is *c*. Albert measures the speed of light from the star to be:

A: slightly less than *c*
B: equal to *c*
C: slightly greater than *c*
D: dependent on the frequency of the light waves.

The longest linear particle accelerator in the world is the Stanford Linear Accelerator (SLAC). Electrons in the SLAC can easily reach speeds of 0.9999*c*. ($\gamma = 70.7$) The length of the SLAC is 3.0km.

Question 7

If the electrons travelled the length of the SLAC at a constant speed of 0.9999*c*, then the time taken for the electrons to travel the length of the SLAC as measured by the SLAC scientists would be:

A: 7.07×10^{-4} s
B: 1.00×10^{-5} s
C: 7.21×10^{-6} s
D: 1.41×10^{-7} s

Question 8

In the electrons frame of reference, how long is the SLAC?

A: 2.12×10^5 m

B: 5.35×10^3 m

C: 3 000 m

D: 42.4m

Question 9

In the electrons frame of reference, how long does it take for electrons to travel the length of the SLAC?

A: 7.07×10^{-4} s

B: 1.00×10^{-5} s

C: 2.31×10^{-6} s

D: 1.41×10^{-7} s

Question 10

In the electrons frame of reference, its mass is 9.1×10^{-31} kg. In the scientist's frame of reference the electron's mass is:

A: 1.29×10^{-32} kg

B: 7.68×10^{-31} kg

C: 9.10×10^{-31} kg

D: 6.37×10^{-29} kg

Question 11

A particle has a total energy of E_T, a kinetic energy of E_K and a rest mass energy of E_{REST}. The expression mc^2 is equal to;

A: E_T

B: E_K

C: E_{REST}

D: $E_T - E_K$

Question 12

An electron has a speed of $0.9c$ ($\gamma = 2.29$) and a rest mass of 9.1×10^{-31}. Its kinetic energy would be:

A: 5.4×10^{-15} J

B: 9.4×10^{-14} J

C: 4.1×10^{-14} J

D: 1.1×10^{-13} J

Detailed study 2 – Materials and their uses

Figure 1 below shows the stress-strain curve for a substance called "material-X" when placed under tension.

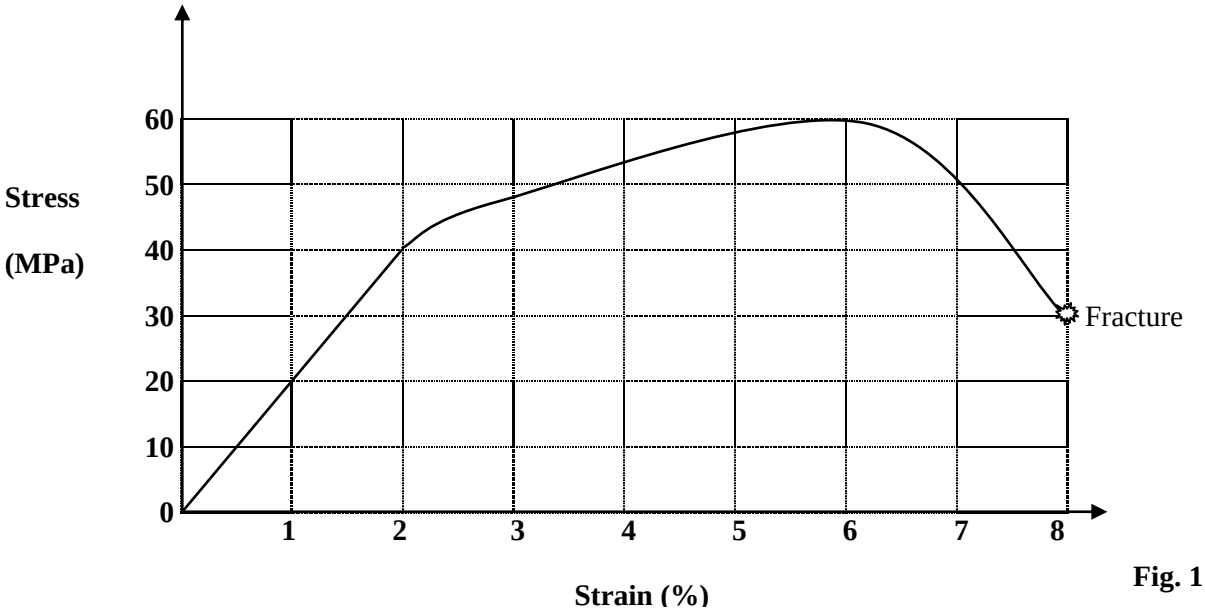


Fig. 1

Question 1
Material-X is in its linear elastic region when it is strained between:

A: 0% and 2%
B: 2% and 6%
C: 6% and 8%
D: 2% and 8%

Question 2
The ultimate tensile strength of Material-X is:

A: 30 MPa
B: 40 MPa
C: 50 MPa
D: 60 MPa

Question 3
The yield strength point of Material-X occurs when it is subjected to a stress of:

A: 30 MPa
B: 40 MPa
C: 50 MPa
D: 60 MPa

Question 4
The breaking strength of Material-X is:
A: 30 MPa
B: 40 MPa
C: 50 MPa
D: 60 MPa

Question 5
Young's modulus for Material-X is:
A: 200MPa
B: 400 MPa
C: 2000 MPa
D: 4000 MPa

Question 6
A 1.0m fibre made from Material-X is subjected to a stress of 40 MPa. Its new length will be:
A: 102 cm
B: 112 cm
C: 120 cm
D: 200 cm

Question 7
The 1.0m fibre has a diameter of 2.0 cm. The maximum mass that could be suspended from the fibre such that the stress is no greater than 1% is approximately:
A: 1200 kg
B: 1000 kg
C: 800kg
D: 600 kg

Question 8
Concrete and steel are used extensively in modern bridges. However hundreds of years ago, bridges were constructed without the use of steel. These were usually made from stone and obtained their strength from their shape which was the arch. The main property of stone which made this possible was:
A: stone is strong under tension
B: stone is strong under compression
C: stone has a high Young's modulus
D: stone has a high yield point

Fig. 2

Question 9

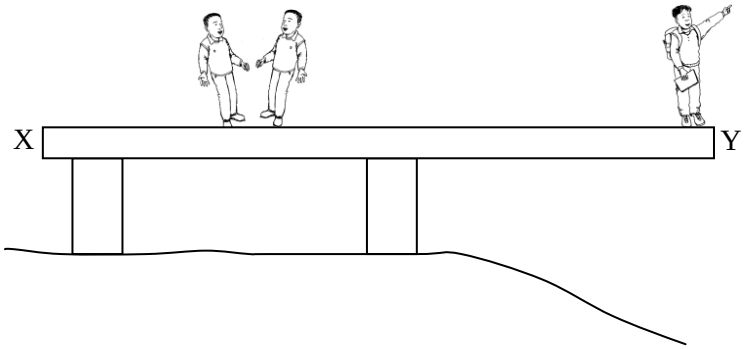


Fig. 3

A viewing platform is to be constructed using two vertical supports and a horizontal slab of concrete. The concrete is to be reinforced with steel rods. Which of the diagrams in Figure 4 below shows the best arrangement of the rods?

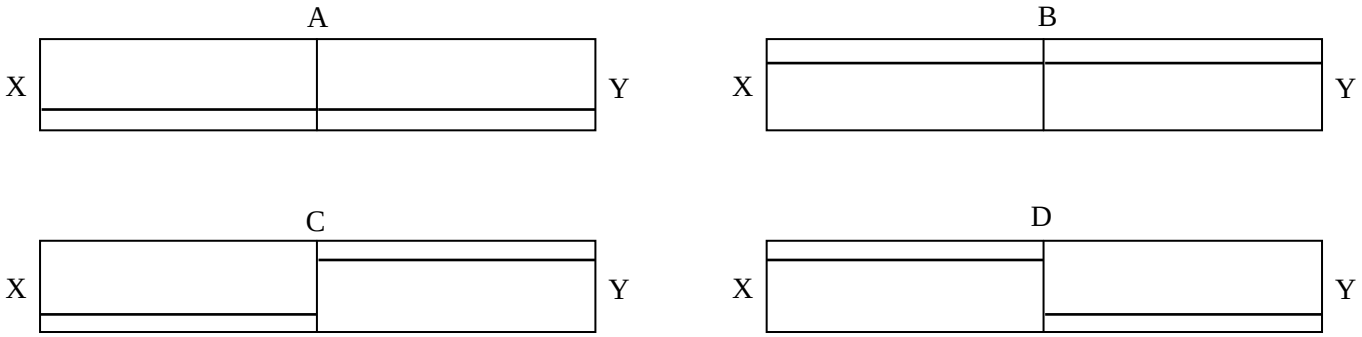


Fig. 4

Question 10

Figure 5 shows an alternative design for the platform. It uses a cable at an angle θ to the horizontal. The horizontal concrete slab has a length *L* and mass *M*. The tension in the cable is *T* and the normal reaction is *N*. Which of the following is correct?

A: $T\cos\theta + N = Mg$

B: $T\sin\theta + N = Mg$

C: $T\cos\theta = MgL$

D: $T\sin\theta = Mg\,L$

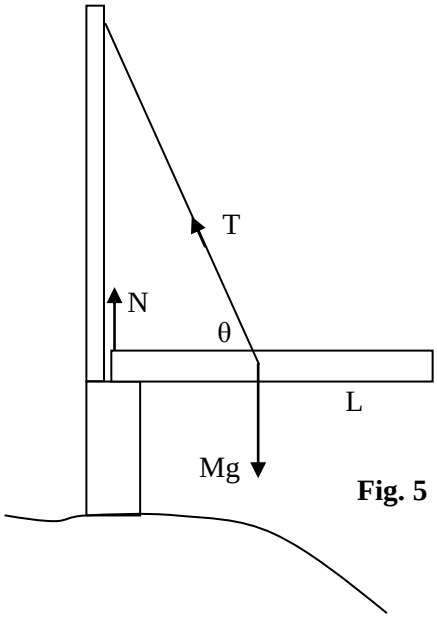


Fig. 5

Figure 6 shows a crane of mass 20 tonne (weight = W = 20 000N) lifting a heavy load, w. The normal reactions at the wheels are N_1 and N_2. The load is too heavy and so the crane is on the point of toppling over.

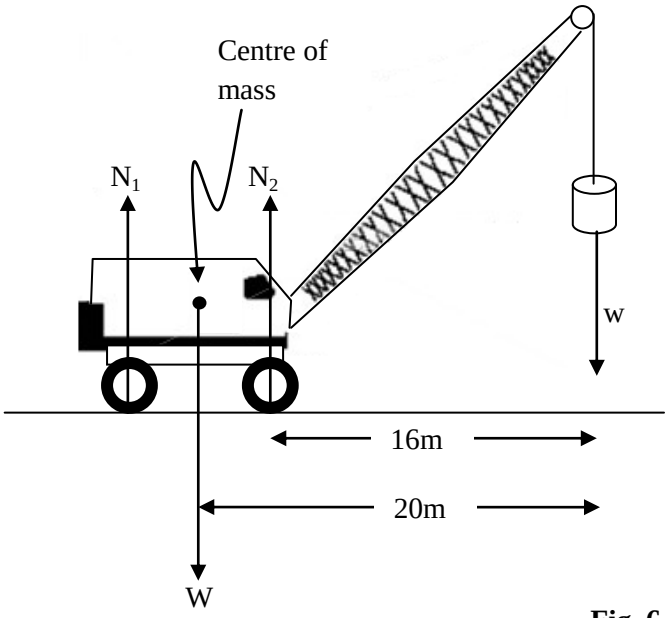


Fig. 6

Question 11

Which of the following is true?

A: $N_1 + N_2 = W$

B: $w > W$

C: $N_1 = 0$

D: $N_2 = 0$

Question 12

The maximum mass that the crane can lift without toppling is:

A: 0.5T

B: 5.0T

C: 10T

D: 15T

Detailed study 3 – Further electronics

Figure 1 to the right represents the display of a CRO when its probes are connected across a 25kΩ resistor that is carrying an AC current. Each small square on the graph has a side length of 1.0 cm. The vertical scale is set to 0.2 V cm^{-1} and the horizontal scale is set to 0.05 ms cm^{-1}.

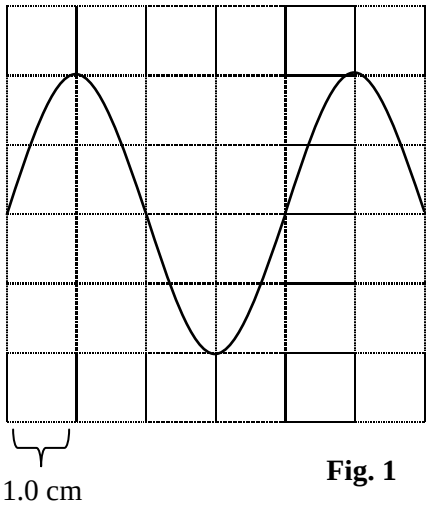


Fig. 1

Question 1
The RMS voltage across the resistor is:
A: 0.28 V
B: 0.40 V
C: 0.57 V
D: 0.63V

Question 2
The frequency of the A.C. signal is:
A: 5.0 mHz
B: 5.0 Hz
C: 5.0 kHz
D: 5.0 MHz

Question 3
The voltage being measured by the CRO is adjusted to $0.50V_{rms}$. The power dissipated by the 25 kΩ resistor is:
A: 0.01 mW
B: 0.10mW
C: 1.0 mW
D: 10 mw

Question 4
A transformer was used to obtain the 0.50 V_{rms} above . The input into the transformer was 240 V_{rms}. If the number of turns on the secondary side was 300, then the number of turns on the input side would be:
A: 36
B: 144
C: 36 000
D: 144 000

Question 5

The $0.5V_{rms}$ supply is connected to a diode and the 25 kΩ resistor as shown in Figure 2 to the right. The CRO settings are adjusted to obtain a clear image. Which of the graphs in Figure 3 below best represents the display on the CRO?

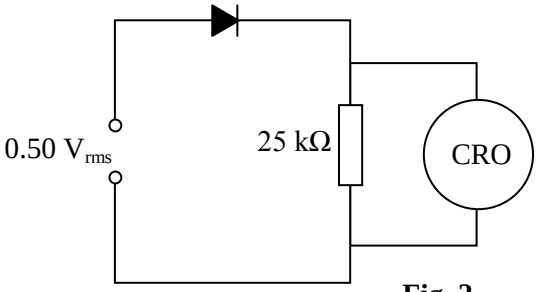
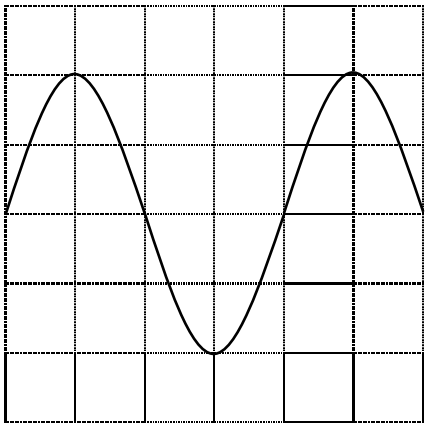


Fig. 2

A



B

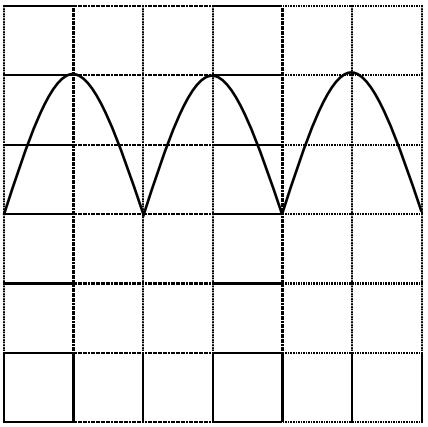
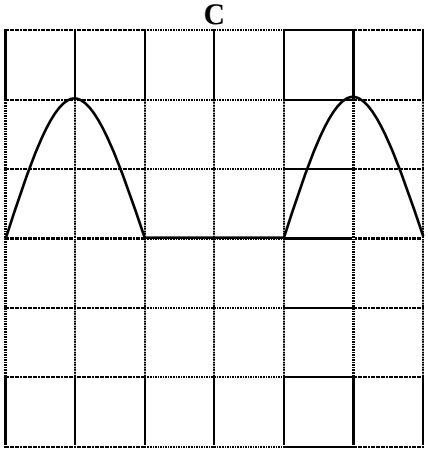
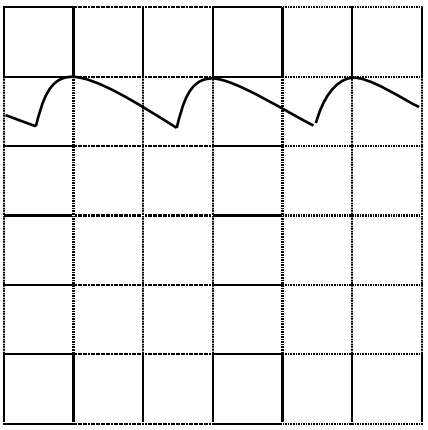


Fig. 3

C



D



Question 6

An 8.0 μF capacitor is connected in parallel with the 25 kΩ resistor. The time-constant for this resistor-capacitor combination is:

A: 0.02s
B: 0.20s
C: 0.31s
D: 3.10s

Question 7

The 0.50 V_{rms} supply is now connected to the diode-capacitor-resistor circuit shown in Figure 4 to the right. The period of the A.C. signal is set to 0.2s. Which of the diagrams in Figure 5 best represents the display on the CRO now? (<u>The time base for the CRO is set to 0.05 ms cm^{-1} as before</u>.)

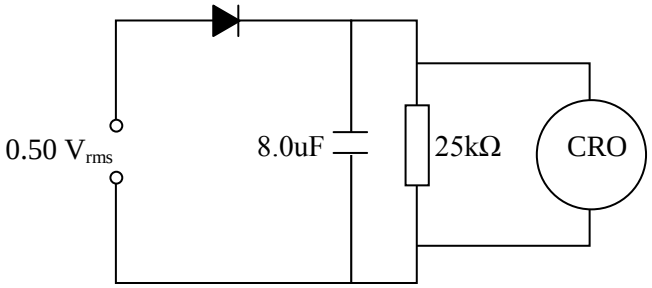
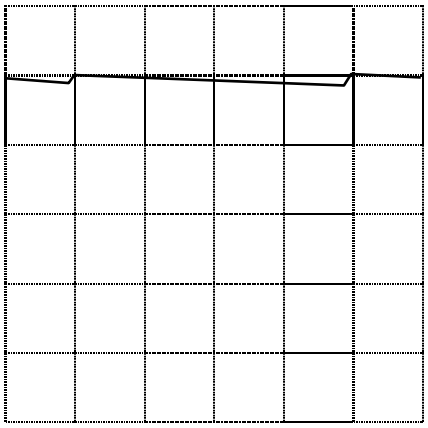


Fig. 4

A



B

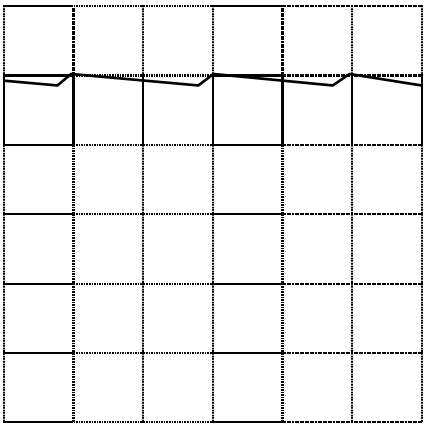
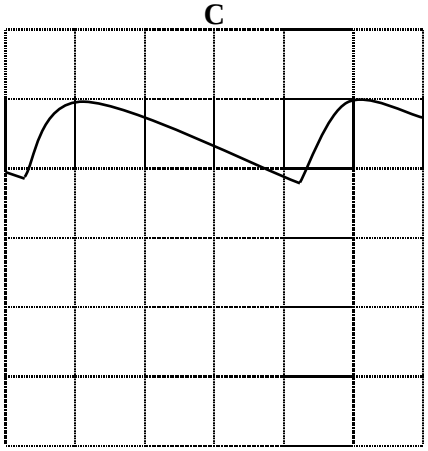
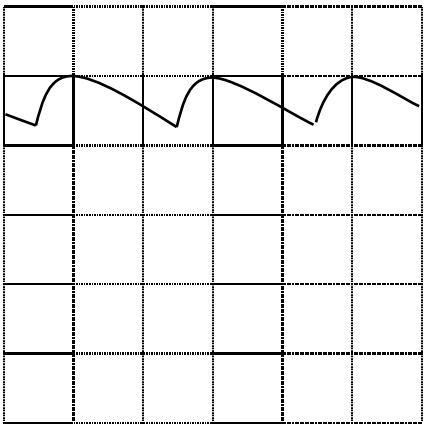


Fig. 5

C



D



Stacey is performing an investigation using a D.C. power supply, a 12V voltage regulator, a resistor and a high quality voltmeter. Her circuit is shown in Figure 6 to the right.

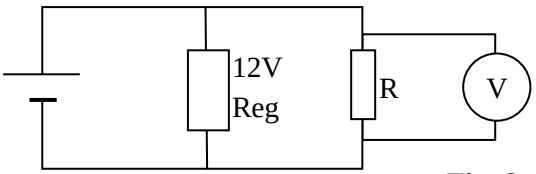


Fig. 6

Question 8

With a 15V DC input, the voltmeter will read:

A: $15\ V$

B: $12\ V$

C: $\frac{15}{\sqrt{2}}\ V$

D: $15\ \times \sqrt{2}\ V$

Question 9

The input is reduced to V volt where V is less than 12. The reading on the voltmeter will be:

A: 12 volt

B: (12 – V) volt

C: (V – 12) volt

D: V volt

Question 10

Stacey's partner, Terri, says that she should have used a CRO in this experiment for two reasons. First, a CRO shows how the output voltage varies with time. Second, a CRO will always give a more accurate reading than a voltmeter. Stacey's most appropriate response is:

A: Good point Terri. Both reasons are correct

B: A CRO does show how the voltage varies with time in this experiment but not all CROs are more accurate than a quality voltmeter

C: There is no variation with time but the CRO will be more accurate

D: You are wrong on both counts. First there will be nothing of interest to see on the CRO and second, just because it's a CRO doesn't mean it is more accurate.

Bill constructs the circuit shown in Figure 7 to the right. The components are a 10 V DC supply, $50\ \mu F$ capacitor, a $200\ k\Omega$ resistor and two switches. He intends using the circuit to investigate the rate at which a capacitor discharges through a resistor. The diagram shows both switches open.

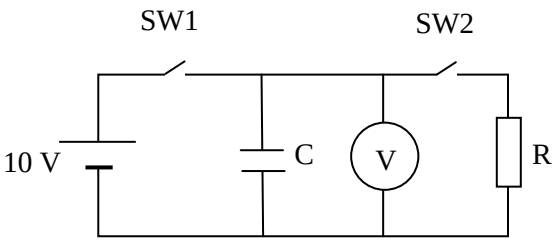


Fig. 7

Question 11

Assuming that the capacitor is initially discharged, he should now:

A: close switch SW1 for about 1 minute, open it then close switch SW2 for about 1 minute

B: close switch SW2 for about 1 minute, open it then close switch SW1 for about 1 minute

C: close switch SW1 for about 1 minute, then close switch SW2 for about 1 minute

D: close switch SW2 for about 1 minute, then close switch SW1 for about 1 minute

Question 12

Bill operates the switches in the correct order so that the fully charged capacitor begins to discharge through the resistor as he starts timing. The reading on the high quality voltmeter after 10 seconds is:

A: Close to zero volt

B: 3.7 volt

C: 6.3 volt

D: Close to 10 volt