INSIGHT

Trial Exam Paper

2010
PHYSICS
Written examination 1

STUDENT NAME:

QUESTION AND ANSWER BOOK

Reading time: 15 minutes

Writing time: 1 hour 30 minutes

Structure of 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	18	18	40
2. Electronics and photonics	11	11	24
B – Detailed Studies			
1. Einstein's special relativity	13	13	26
OR			
2. Investigating materials and their use in structures	13	13	26
OR			
3. Further electronics	13	13	26
Total			90

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

Materials provided

- The question and answer book of 45 pages, with a separate data sheet.

Instructions

- Write your **name** in the box provided.
- Remove the data sheet during reading time.
- Answer all the questions in the space provided.
- Unless otherwise indicated, the diagrams in this book are **not** drawn to scale.
- You must answer all questions in English.

Students are NOT permitted to bring mobile phones or any other electronic device into the examination.

SECTION A – Core

Area of study 1 – Motion in one and two dimensions

Instructions for Section A

Answer **all** questions for **both** Areas of study in this section of the paper.

The following information relates to Questions 1 and 2.

A container full of sand is pulled up an incline by a cable, as shown in Figure 1. The combined mass of the container and sand is 1400 kg.

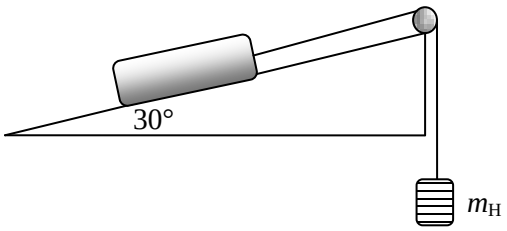

Figure 1

Question 1

If the cable suddenly broke, what would be the magnitude of the acceleration of the container down the incline?

_____

_____

_____

m s^{-2}

2 marks

Question 2

When the hanging mass, m_H, is 800 kg the full container is found to move at a constant speed. What is the force of friction acting on the container?

N

2 marks

Question 3

If the hanging mass, m_H, is increased to 1000 kg and the friction force stays the same, what is the magnitude of the container's acceleration now?

m s^{-2}

2 marks

The following information relates to Questions 4 to 6.

Bruce pushes two blocks, B_1 and B_2, with a force of 45 N. As a result, the two blocks move together along a floor to the right, as shown in Figure 2. The blocks have a mass of 16 kg and 8 kg, respectively, and they encounter constant friction force of 7 N and 3 N, respectively.

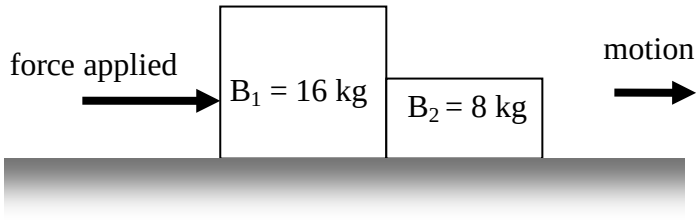

Figure 2

Question 4

What is the magnitude of the acceleration of block B_1?

m s^{-2}

2 marks

Question 5

What is the magnitude of the force exerted by B_1 on B_2? Show your working.

N

2 marks

Question 6

What is the force magnitude of the force exerted by B_2 on B_1? Show your working.

N

2 marks

The following information relates to Questions 7 and 8.

Figure 3 shows a bike rider going around a banked surface in uniform circular motion in a radius of 5.0 m. The combined mass of the bike and the rider is 135 kg and the angle of the bank is 15.0°.

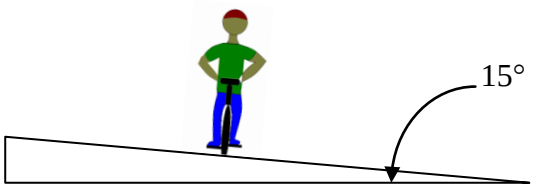

Figure 3

Question 7

On Figure 3, draw an arrow to show the direction of net force on the rider.

1 mark

Question 8

What is the maximum safe speed of the rider, without taking into account any contributing effects of friction?

m s^{-1}

3 marks

Question 9

What is the magnitude of the net force acting on the combined bike and rider?

N

2 marks

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The following information relates to Questions 10 to 12.

A joy ride consists of passengers in a cart that runs on the inside of a vertical circle of radius 3.2 m, as shown in Figure 4. Kevin, who has a mass of 80 kg, rides in the carriage and is strapped firmly in his seat. The carriage runs at a constant speed at all times.

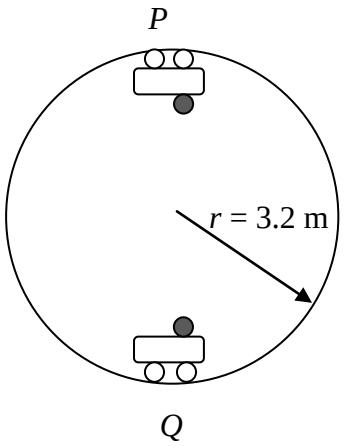

Figure 4

Question 10

Calculate the minimum speed the carriage must have at the top of the circle, location *P*, to ensure that it continues to move in a uniform circular motion.

m s^{-1}

2 marks

Question 11

What is the apparent weight of Kevin at the bottom of the ride, at location *Q*?

N

2 marks

Question 12

At point *P*, Kevin says he felt 'weightless'. Explain, making reference to the reason why he felt so.

_____

_____

_____

1 mark

The following information relates to Questions 13 and 14.

A communications satellite called AUSSAT-I of mass 1200 kg is orbiting Earth at an altitude of 650 km.

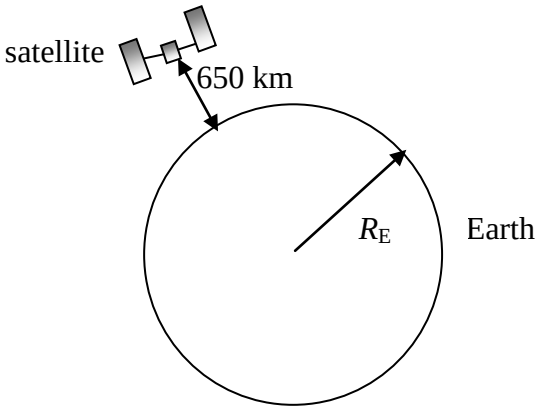

Figure 5

Question 13

Calculate the satellite's speed.

m s^{-1}

3 marks

Question 14

At what height above the Earth's surface would the satellite's weight be 90% of its weight on the surface of Earth? Use gravitational field strength on the surface of Earth as 9.8 m s^{-2}.

3 marks

The following information relates to Questions 15 and 16.

A projectile of mass 2.0 kg is shot with an initial speed of 10.0 m s^{-1} at an angle of 30° to the horizontal, as shown in Figure 6.

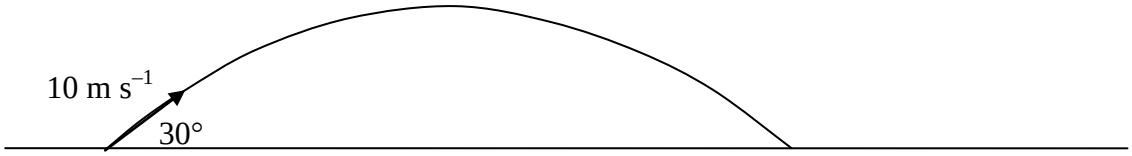

Figure 6

Question 15

Calculate the speed of the projectile 0.6 s after launch.

m s^{-1}

4 marks

Question 16

Calculate the kinetic energy of the projectile 0.6 s after launch. Show your working.

J

2 marks

The following information relates to Questions 17 and 18.

Ayden is riding a trolley and they are moving at a constant speed of 15.0 m s^{-1} at a certain time t_0. At one point Ayden decides to jump off the trolley and does so in the same direction as the trolley at a speed of 5.0 m s^{-1}, as shown in Figure 7. Ayden's mass is 45 kg and the trolley's mass is 30 kg.

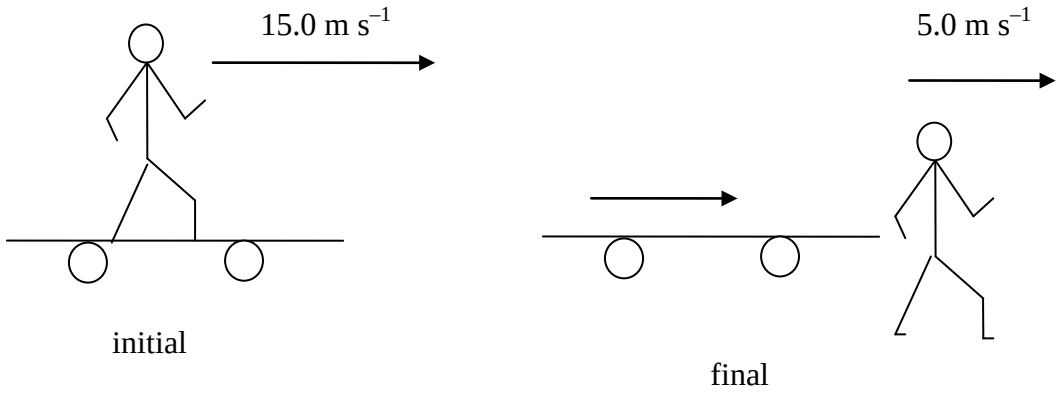

Figure 7

Question 17

What is the speed of the trolley just after Ayden jumps off?

m s^{-1}

2 marks

Question 18

Travelling in a straight line, the trolley comes to a stop at a distance 25.0 m away owing to the force of friction, $\boldsymbol{F}_f$, between the trolley and the floor. Assuming that $\boldsymbol{F}_f$ is a constant force, find its magnitude. Show your working.

N

3 marks

SECTION A – End of Area of study 1
TURN OVER

SECTION A – Core
Area of study 2 – Electronics and photonics

The following information relates to Questions 1 to 3.

Jamie assembles a circuit with a 1.5 V battery, two silicon diodes called P and Q, and two 1000 Ω resistors, as shown in Figure 1. The voltage-current characteristic graph of the silicon diode is shown in Figure 2.

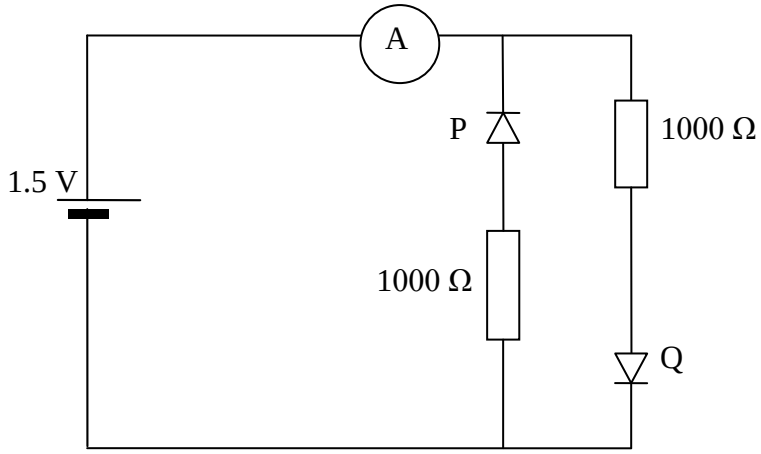

Figure 1

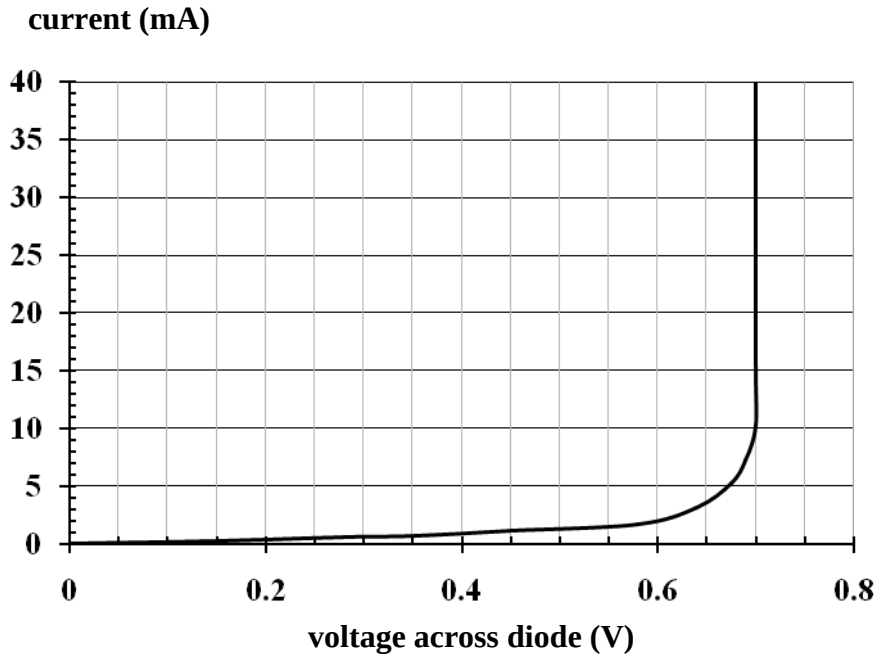

Figure 2

Question 1

Calculate the current in the ammeter for the circuit assembled by Jamie.

mA

2 marks

Question 2

Stacey comes along and removes diode P and replaces it with a 2000 Ω resistor, as shown in Figure 3. What is the reading in the ammeter now?

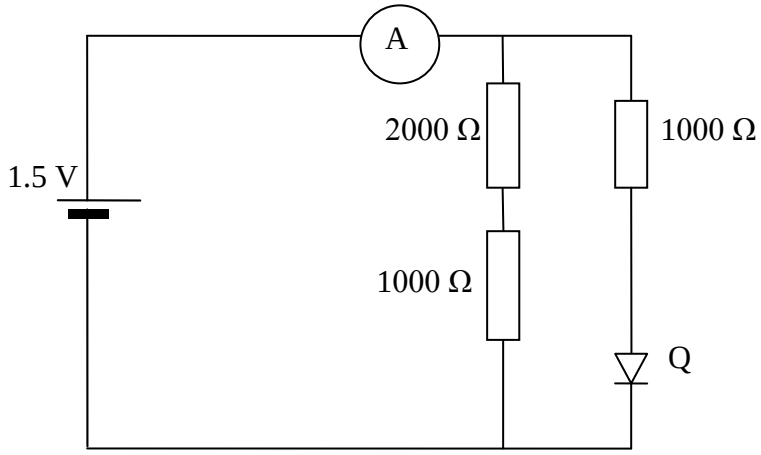

Figure 3

mA

3 marks

Question 3

Referring to the circuit set up by Stacey, calculate the energy lost in the 2000 Ω resistor in 60 s.

J

2 marks

The following information relates to Questions 4 and 5.

A streetlight uses a light-emitting diode (LED) to switch the light on or off. A simplified version of the circuit is shown in Figure 4a. The road engineers researching the LED compiled the graph shown in Figure 4b, which shows the variation of resistance with time of day.

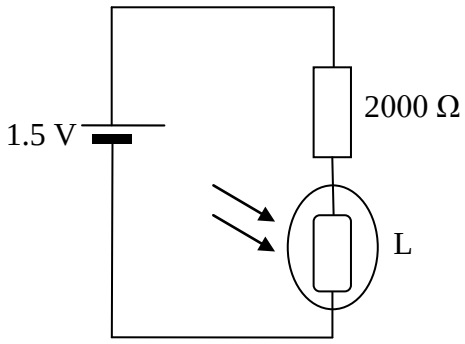

Figure 4

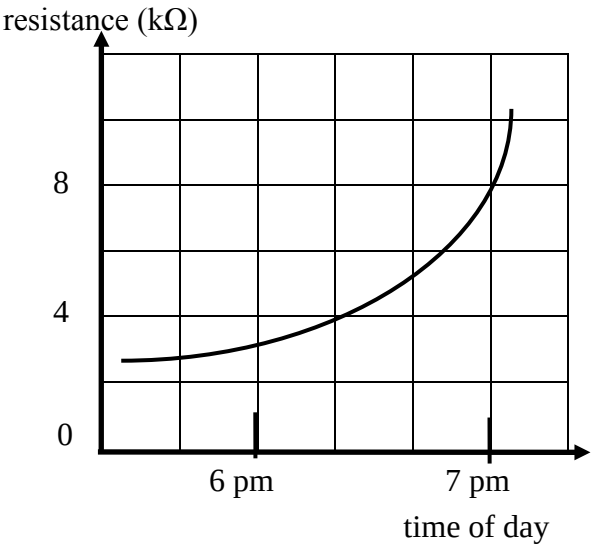

Figure 4b

Question 4

Calculate the ratio of the current in the circuit at 6.00 pm to that at 7.00 pm.

3 marks

Question 5

During bright daylight, would you expect the voltage across the resistor to increase or decrease? Explain your reasoning.

2 marks

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The following information relates to Questions 6 to 8.

The performance of two amplifiers is being studied by means of an oscilloscope, which measures input and output signals. The characteristic graphs of the two different amplifiers are shown in Figure 5.

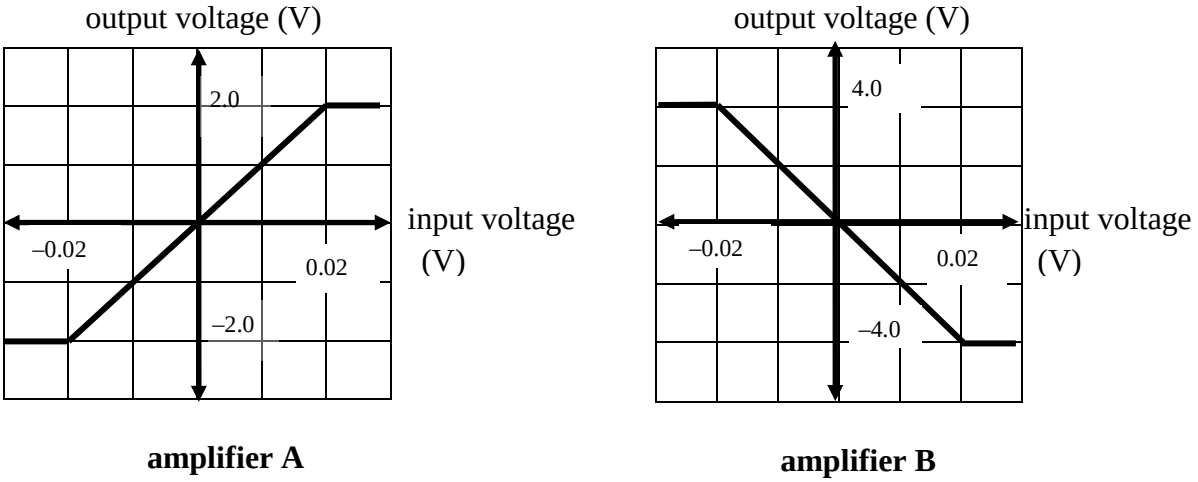


Figure 5

Figure 6 shows the test input signal fed through the amplifiers one at a time.

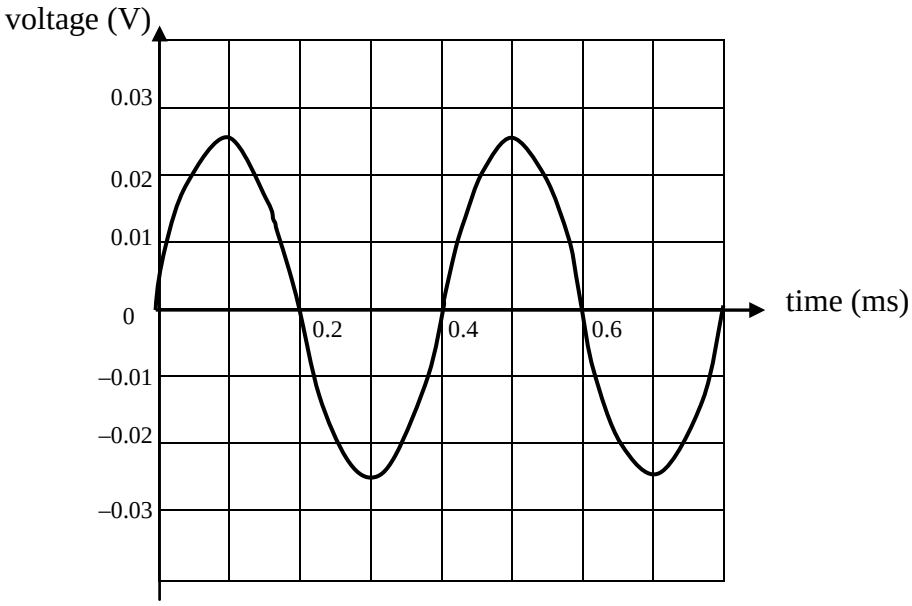
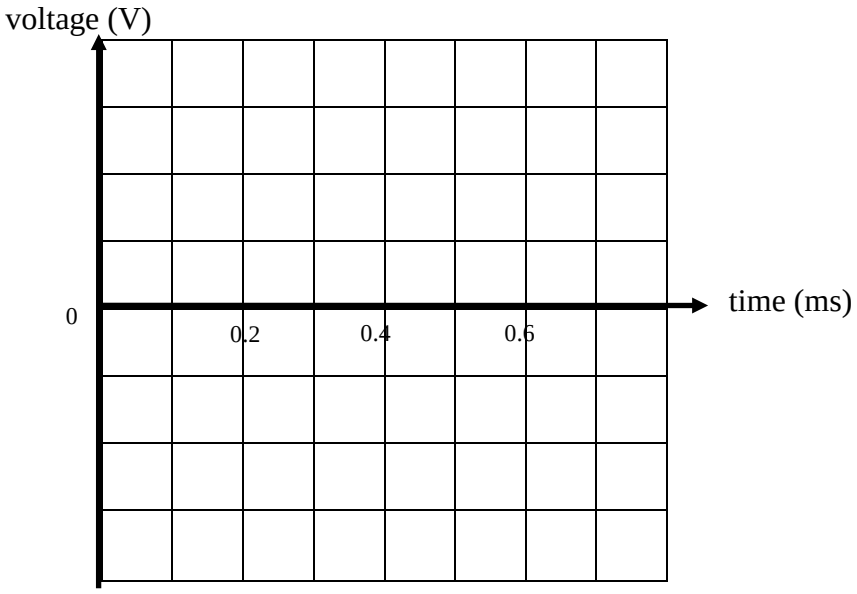


Figure 6

Question 6

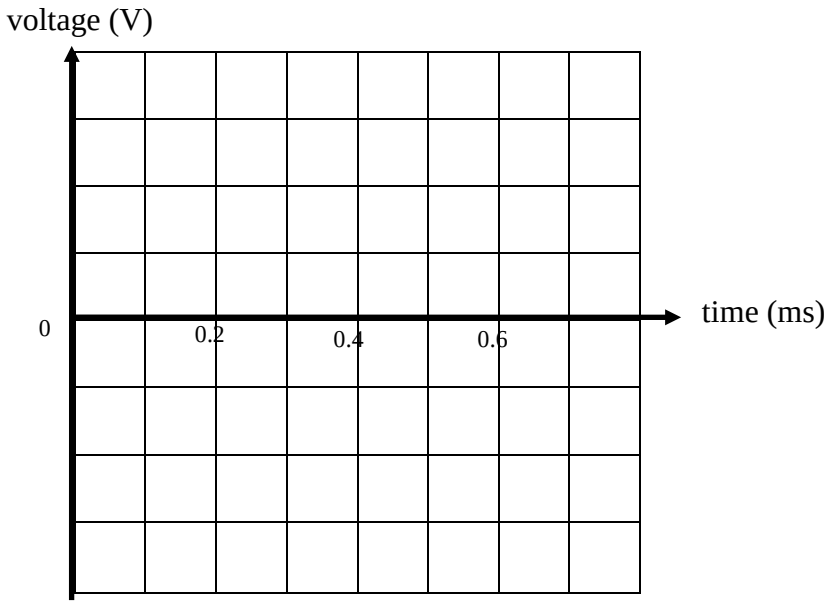
On the axes below draw the output graph when the given input signal is fed through amplifier A. Select an appropriate scale on the *y*-axis.



2 marks

Question 7

On the axes below draw the output graph when the given input graph is fed through amplifier B. Select an appropriate scale on the *y*-axis.



2 marks

Question 8

Calculate the ratio of the voltage gain of amplifier A to that of amplifier B.

2 marks

The following information relates to Question 9.

The signal shown in Figure 7a is to be transmitted as a modulated signal using the carrier wave shown in Figure 7b.

Figure 7

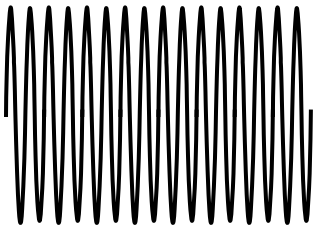
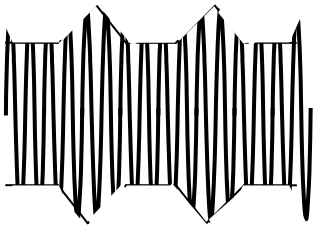


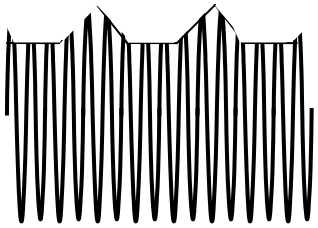
Figure 7b

Question 9

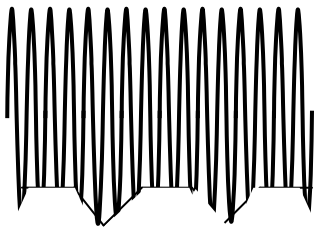
Which one of the following four figures best represents the modulated carrier?



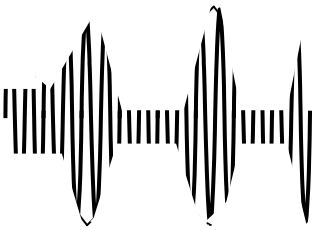
A.



B.



C.



D.

2 marks

The following information relates to Questions 10 and 11.

A photodiode exhibits the following photocurrent behaviour when illuminated with different light intensity, Φ. It is being used as a switch where the variations in light intensity cause a proportional response to voltage measured across a resistor.

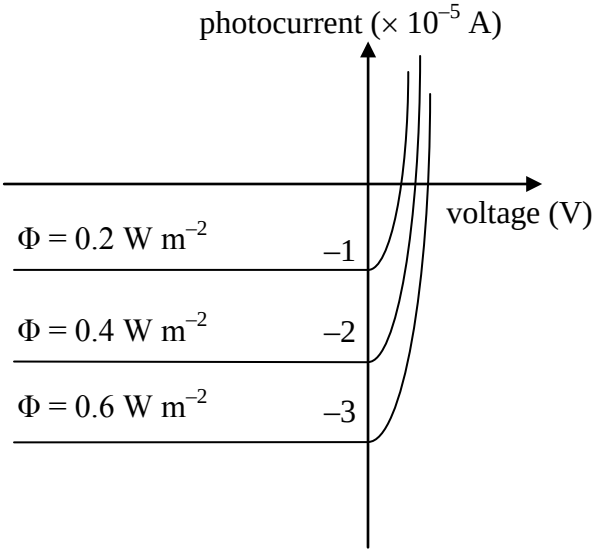
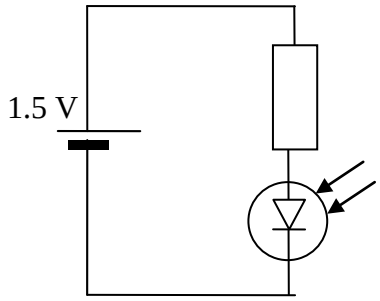


Figure 8

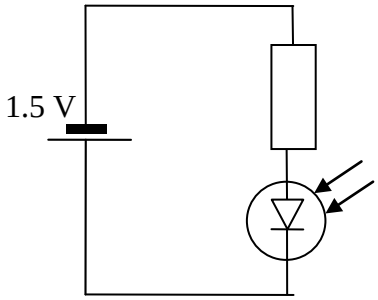
Question 10

Which one of the following is the best circuit for using the photodiode as a switch?

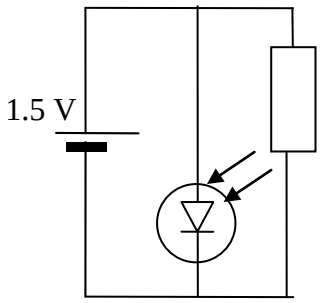
A.



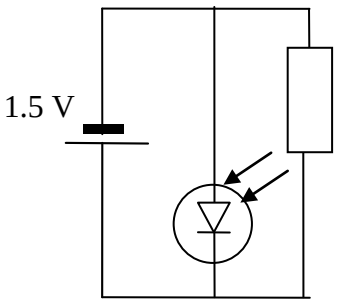
B.



C.



D.



2 marks

Question 11

The photodiode described in Figure 8 is used as a switch in reverse bias in order to detect an intruder. What is the voltage across a 1000 Ω resistor to which the photodiode is connected in reverse bias and light of intensity 0.4 W m^{-2} illuminates the photodiode?

_____

_____

_____

V

2 marks

END OF SECTION A
TURN OVER

SECTION B – Detailed studies

Instructions for Section B

Choose **one** of the following **Detailed Studies**. Answer **all** the questions on the Detailed Study you have chosen.

Detailed study 1 – Einstein's special relativity

The following information relates to Questions 1 and 2.

In the year 2300 AD, a spaceship is sent at a speed of 0.9 *c* to a star 30 light-years away.

Question 1

Which one of the following gives the time taken for the spaceship to reach the star, as determined by an observer on Earth?

A. 27.0 years
B. 33.3 years
C. 60.0 years
D. 14.5 years

Question 2

Which one of the following gives the time taken for the spaceship to reach the star, as determined by an observer on the spaceship?

A. 33.3 years
B. 27.0 years
C. 14.5 years
D. 60.0 years

Question 3

An asteroid flies past Earth's outer atmosphere at 0.7*c*. Astronauts on the space station measure its length to be 110 m. Which one of the following is the closest in magnitude to the length the astronauts would have measured the asteroid to be if they had actually landed on the asteroid?

A. 134 m

B. 145 m

C. 154 m

D. 165 m

Question 4

Which one of the following statements is **not** part of Einstein's special theory of relativity?

A. The speed of light in vacuum does not depend on the speed of the observer or the source.

B. The laws of physics are the same for an observer, whichever reference frame the observer may be in.

C. The speed of light in vacuum is the same in all inertial reference frames.

D. The laws of physics are the same *only* in a stationary reference frame.

Question 5

For an object travelling close to the speed of light, which one of the following statements is most likely to be true?

A. Proper time is > relativistic time, and proper length < relativistic length.

B. Proper time is < relativistic time, and proper length > relativistic length.

C. Proper time is > relativistic time, and proper length > relativistic length.

D. Proper time is < relativistic time, and proper length < relativistic length.

Question 6

Which one of the following gives the rest energy of an electron?
Mass of electron is 9.1×10^{-31} kg.

A. 8.2×10^{-14} J
B. 4.1×10^{-14} J
C. 2.5×10^{-13} J
D. 2.7×10^{-14} J

Question 7

Which one of the following is the closest in value to the mass of an electron moving with a speed of 0.68 *c*?

A. 1.6×10^{-31} kg
B. 9.1×10^{-31} kg
C. 1.2×10^{-30} kg
D. 6.7×10^{-31} kg

Question 8

Which one of the following gives the kinetic energy of an electron moving at the speed of 0.68 *c*?

A. 9.9×10^{-15} J
B. 8.2×10^{-14} J
C. 2.7×10^{-13} J
D. 1.7×10^{-14} J

The following information relates to Questions 9 and 10.

In the experiment conducted by Michaelson and Morley, light was shone from a source to a half-silvered mirror, such that part of the light reflected to mirror M_1 and the other part transmitted to M_2. A simplified diagram of the experimental set-up is shown in Figure 1.

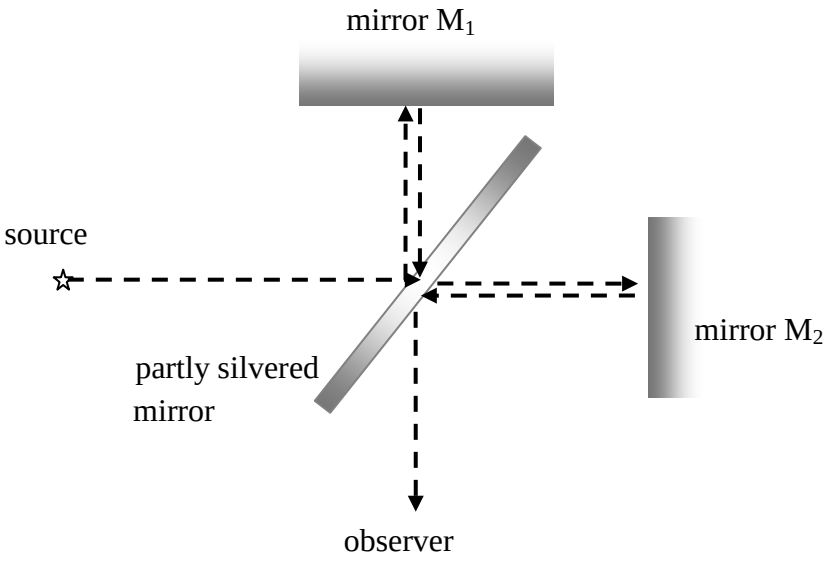


Figure 1

Question 9

Which one of the following properties of light was fundamental to the understanding of the experiment?

A. reflection
B. interference
C. diffraction
D. refraction

Question 10

Which one of the following statements is **incorrect** about the experiment and what it set out to achieve?

A. The experiment was designed to measure the speed of ether relative to Earth.

B. The experiment hoped to discover an absolute reference frame.

C. The experiment was based on the speed of light being constant in all inertial reference frames.

D. For the experiment to be successful it was vital that the half-silvered mirror allowed exactly half the light to get to each mirror.

Question 11

Which one of the following statements **best describes** inertial reference frames?

A. They do not move.

B. They move with constant acceleration.

C. They move with zero acceleration.

D. They move with increasing acceleration.

Question 12

Two spaceships, Freddie and Khokho, fly in the opposite direction from a space launching pad, each with a speed of 0.65 *c*, as shown in Figure 2.

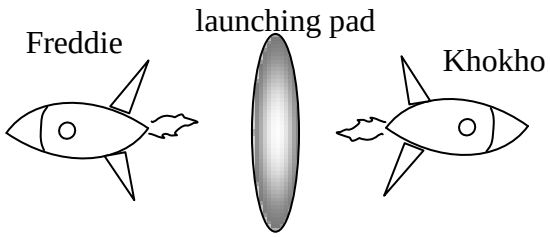


Figure 2

What is the speed of Freddie as measured by an observer on Khokho?

A. 1.3 *c*

B. 0.65 *c*

C. 0.91 *c*

D. 0.79 *c*

Question 13

Which of the following **best represents** the mass of an object as it approaches a speed close to that of light?

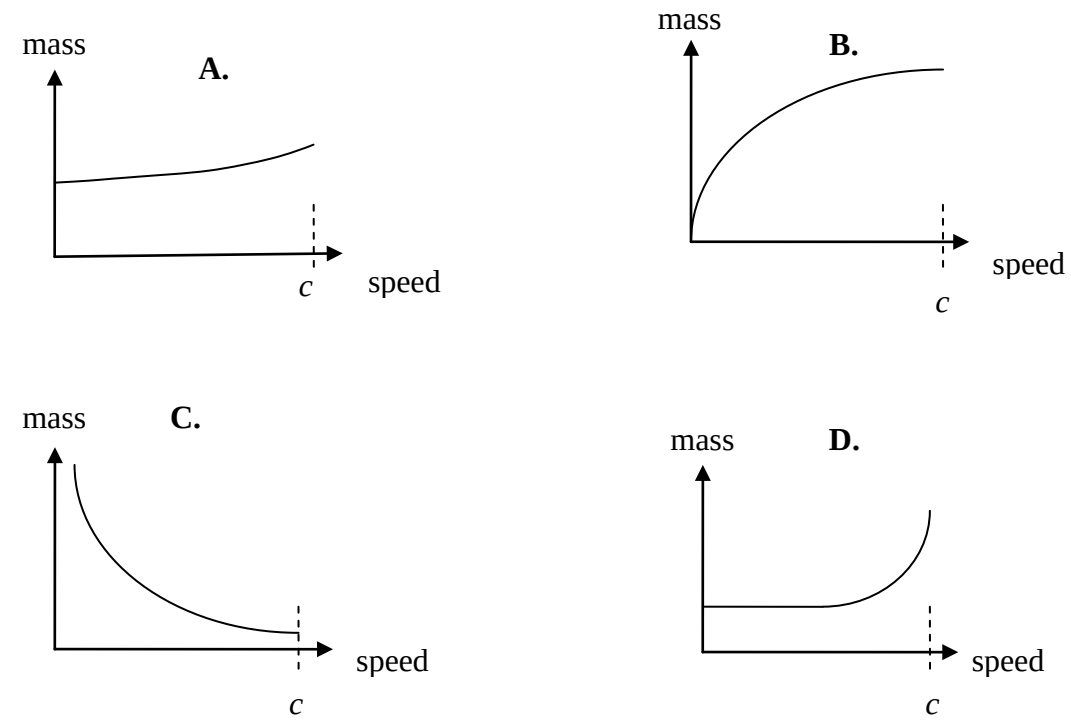


Figure 3

SECTION B – Detailed studies
Detailed study 2 – Materials and their use in structures

The following information relates to Questions 1 to 5.

The stress–strain graphs until fracture for three different materials being tested under tension in a laboratory are shown in Figure 1. Each sample is 5.0 cm long and has a square cross-section of dimensions 1.0 cm × 1.0 cm) [1 MPa = 10^6 Nm^{-2}].

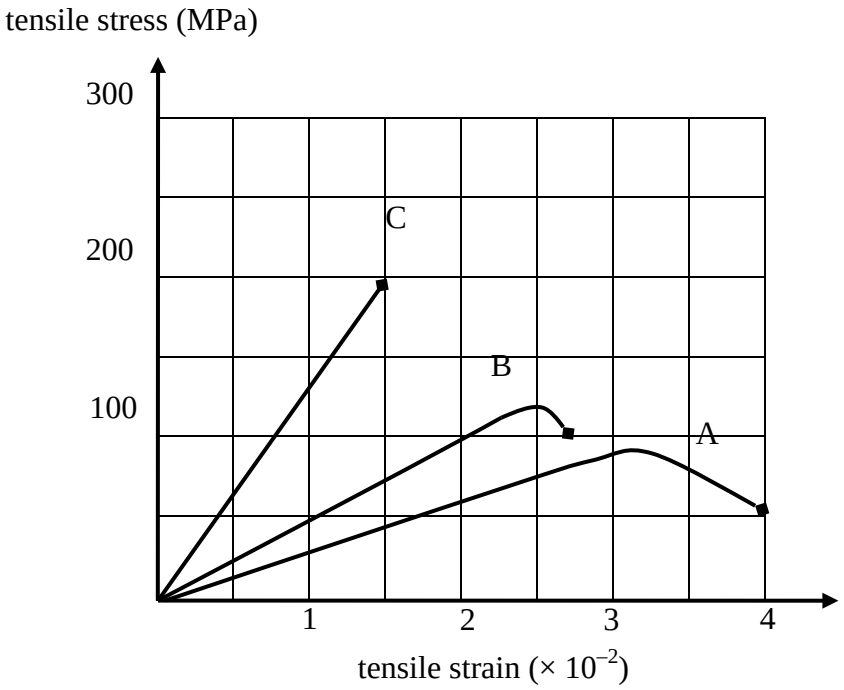


Figure 1

Question 1

Regarding the three materials, which of the following statements is **correct**?

A. C is brittle and B is tougher than A.
B. C is brittle and A is tougher than B.
C. A is brittle and B is tougher than A.
D. B is brittle and C is tougher than A.

Question 2

Young's modulus of material C is closest in magnitude to

A. 133.3 MPa

B. 1.3×10^5 MPa

C. 1.3×10^4 MPa

D. 1.5 MPa

Question 3

The force needed to extend material B from its original length of 5.0 cm to a length of 5.1 cm is closest in value to

A. 1000 N

B. 10 000 N

C. 100 000 N

D. 100 N

Question 4

When a tensile stress of 200 MPa is applied to material A, the strain energy per unit volume in the sample is

A. 7.5 J m^{-3}

B. 7.5×10^3 J m^{-3}

C. 1500 J m^{-3}

D. 1.5×10^6 J m^{-3}

Question 5

The spring constant of material B in the elastic region is

A. 1.0×10^7 N m^{-1}

B. 5000 MPa

C. 5000 N m^{-1}

D. 10^7 Pa

The following information relates to Questions 6 and 7.

Tahlia stands 0.40 m away from the end of a 2.40 m wooden plank. The plank is fixed firmly into a wall, as shown in Figure 2. The mass of Tahlia is 70.0 kg and that of the plank is 35.0 kg.

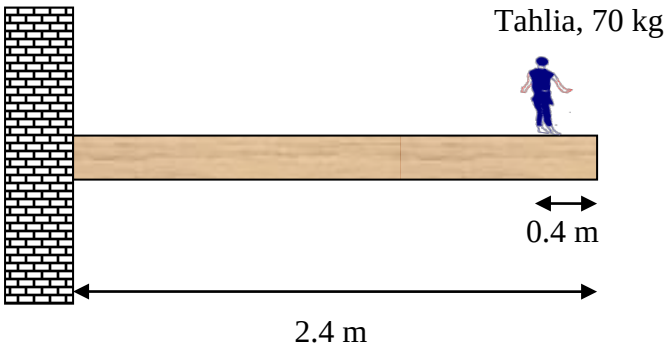


Figure 2

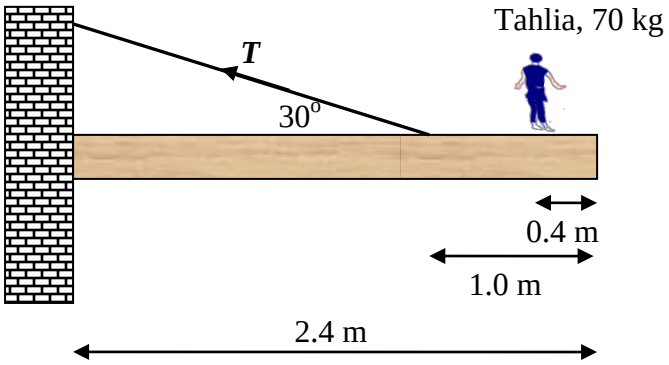
Question 6

Which one of the following is the **best estimate** of the torque exerted by Tahlia on the wall?

A. 1680 N m
B. 140 N m
C. 1400 N m
D. 280 N m

Question 7

To strengthen the structure further, John ties a cable to the structure 1.0 m from the plank's end at an angle of 30° to the horizontal, as shown in Figure 3, and also places a hinge between the plank and the wall. Which of the following is the magnitude of the tension force in the cable?



A. 2600 N
B. 1501 N
C. 1050 N
D. 909 N

Question 8

Caroline is sitting on a see-saw 1.5 m away from its centre. Jack then sits down at the see-saw's other end such that the plank is balanced perfectly horizontal, as shown in Figure 3. The mass of Caroline is 60.0 kg and Jack is 70.0 kg. How far from the centre of the plank, *R*, did Jack sit? Select the best answer from the options provided.

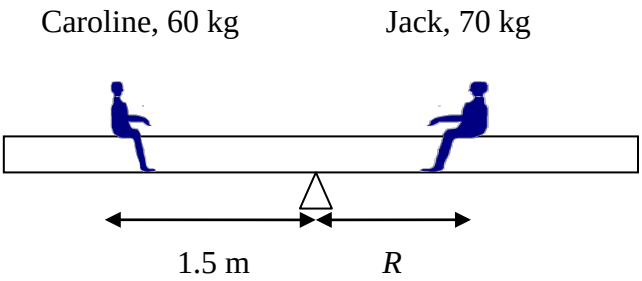


Figure 3

A. 1.1 m

B. 1.5 m

C. 1.4 m

D. 1.3 m

The following information relates to Questions 9 and 10.

A shop sign of mass 20.0 kg is strung up at the entrance of the shop by two cables to the roof and the side wall, as shown in Figure 4. The shop sign is in equilibrium.

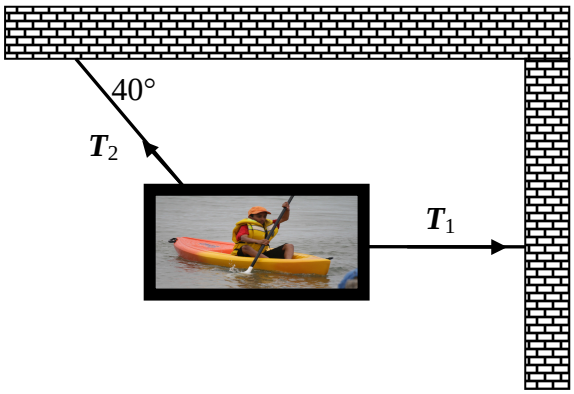


Figure 4

Question 9

Which one of the following is the closest in magnitude of the force $\boldsymbol{T}_1$?

A. 238 N

B. 311 N

C. 200 N

C. 261 N

Question 10

Which one of the following is the closest in magnitude of the force $\boldsymbol{T}_2$?

A. 238 N

B. 311 N

C. 200 N

D. 261 N

The following information relates to Questions 11 to 13.

Wires of two materials, sample A and sample B, are being investigated by applying a tensile force on them. Each sample is 6.0 cm long and has a cross-sectional area of 3.0×10^{-8} m^2. The force versus extension behaviour of the two materials is shown in Figure 5.

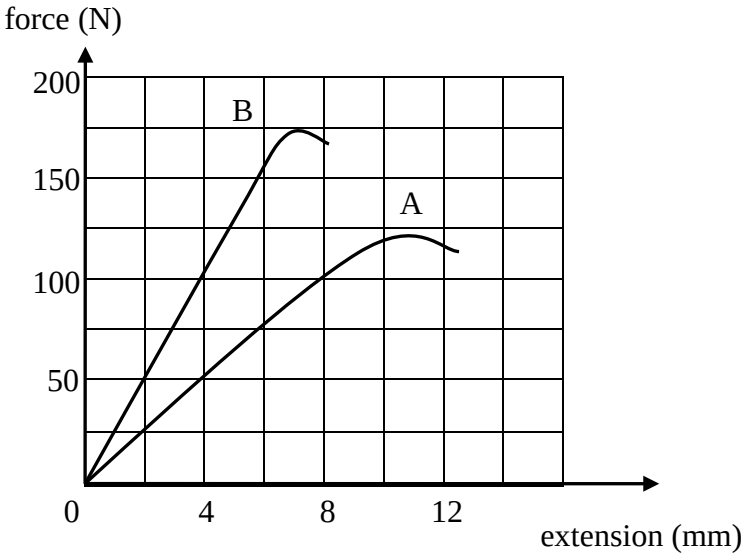


Figure 5

Question 11

Which one of the following is the closest in magnitude to the spring constant of sample A?

A. 50 N m
B. 12500 N m^{-1}
C. 12.5 N m^{-1}
D. 0.05 N m

Question 12

A mass of 5.0 kg is suspended from sample B. The stress applied to the sample is then closest in magnitude to

A. 150×10^8 N m^{-2}
B. 150×10^8 MPa
C. 1670 MPa
D. 1670×10^8 N m^{-2}

Question 13

Which one of the following is the ratio of Young's modulus of sample A to that of sample B?

A. 1 : 2

B. 2 : 1

C. 2 : 5

D. 5 : 2

END OF DETAILED STUDY 2
SECTION B – continued
TURN OVER

SECTION B – Detailed studies
Detailed study 3 – Further electronics

The following information relates to Questions 1 to 3.

Gabriela desires to have a rectified power supply for a load resistor device whose resistance is R_L to be initially equal to 500 Ω. She assembles the circuit shown in Figure 1, which consists of a 240 V_{RMS}, 50 Hz supply, a transformer and a 200 μF capacitor. The transformer has a ratio of turns primary : secondary of 10 : 1 Gabriela studies the voltage–time waveform across various points of the circuit using a cathode ray oscilloscope (CRO).

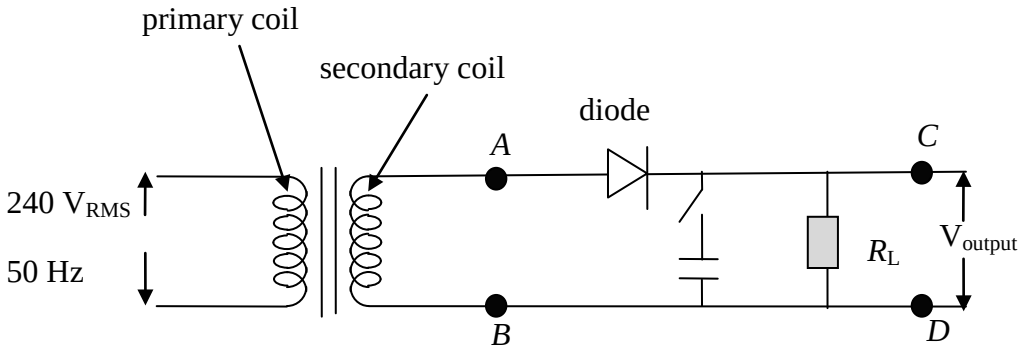


Figure 1

Question 1

When the CRO is connected across the points *A* and *B*, the following trace is observed (see Figure 2).

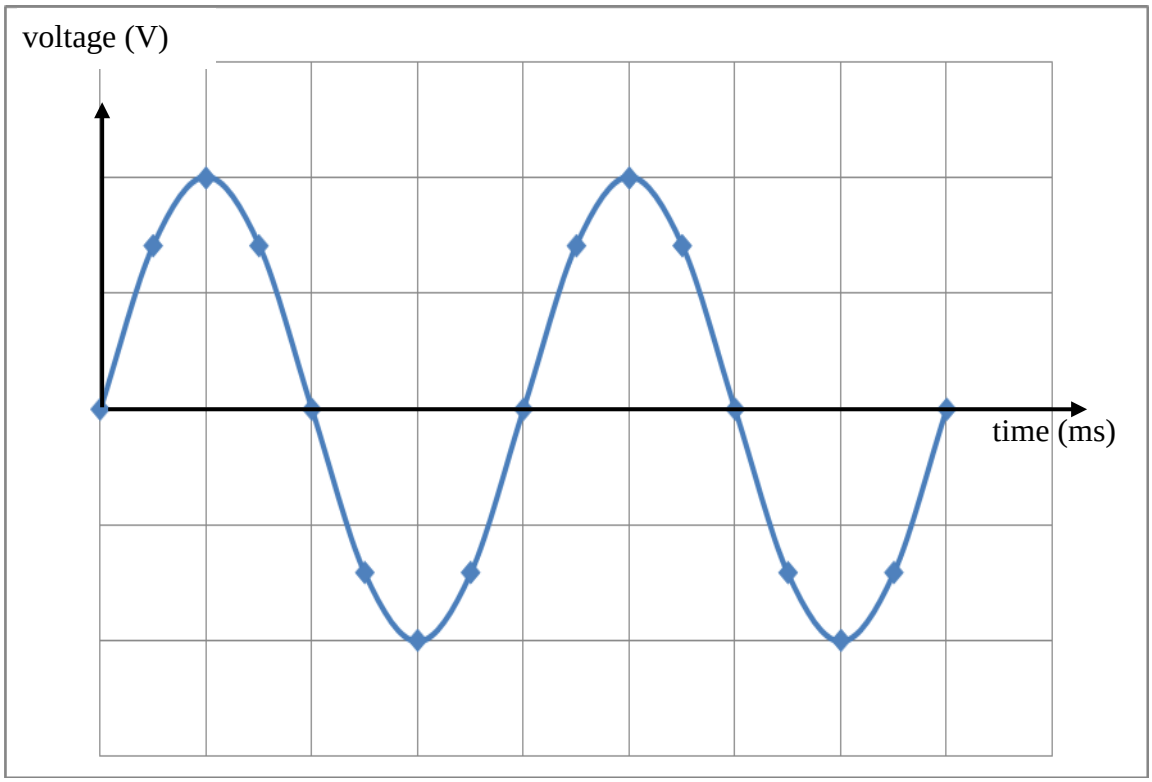


Figure 2

Which of the following statements is the best representation of the *x*-axis and *y*-axis *scale* for the CRO trace? Each square in the figure represents sides of 1 cm.

A. 1 cm = 20 ms, 1 cm = 17 V

B. 1 cm = 0.01 ms, 1 cm = 120 V

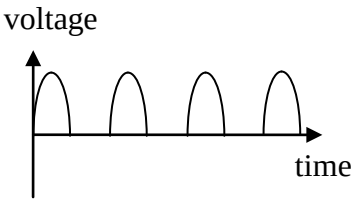
C. 1 cm = 5 ms, 1 cm = 17 V

D. 1 cm = 10 ms, 1 cm = 24 V

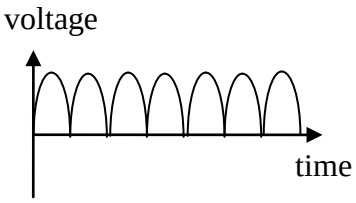
Question 2

Gabriela now connects the CRO across points *C* and *D*. With the switch **disconnected**, the voltage waveform across points *C* and *D* is closest *in shape* to which one of the following?

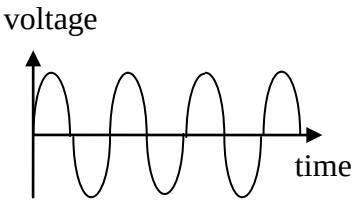
A.



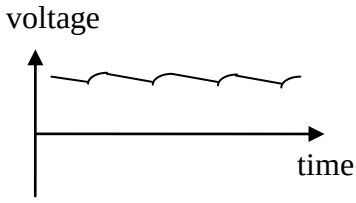
B.



C.



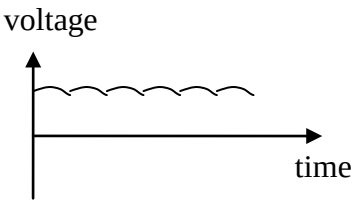
D.



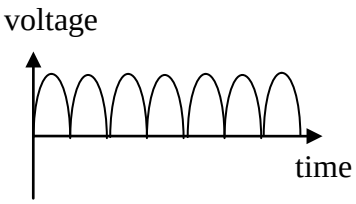
Question 3

With the switch now *on* so that the capacitor is part of the circuit, which of the following is the **best representation** of the wave form across points *C* and *D*?

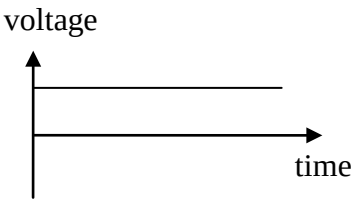
A.



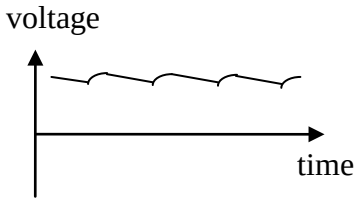
B.



C.



D.



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The following information relates to Questions 4 to 7.

An RC circuit is assembled as shown in Figure 3. It consists of a switch, a 6.0 V battery, a 5000 Ω resistor and a 500 μF capacitor. The variation of voltage with time across the capacitor and resistor is then studied.

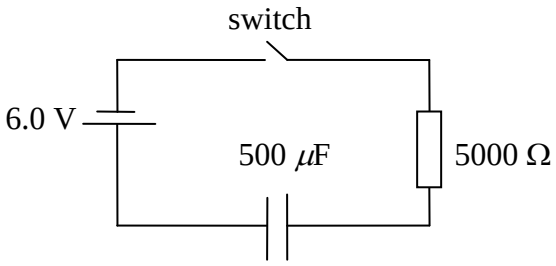


Figure 3

Question 4

Which one of the following is the **best estimate** for the time constant of the RC circuit?

A. 2500 s

B. 100 s

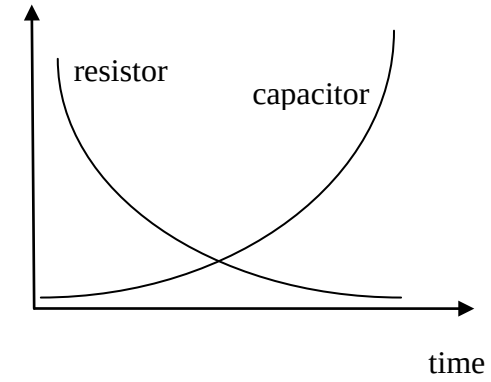
C. 2.5 s

D. 1.0 s

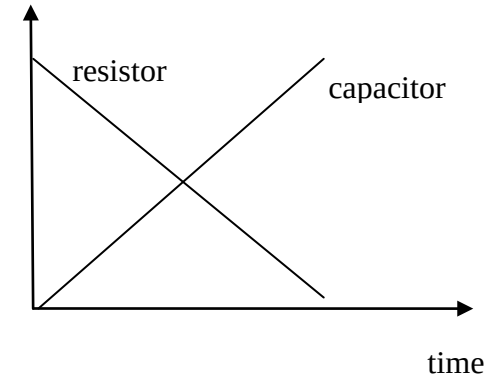
Question 5

When the switch is **closed** and the **circuit is fully connected**, which of the following graphs best describe the behaviour of *voltage* with *time* across the resistor and the capacitor?

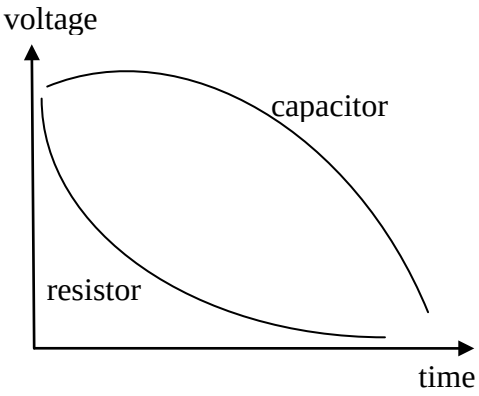
A.



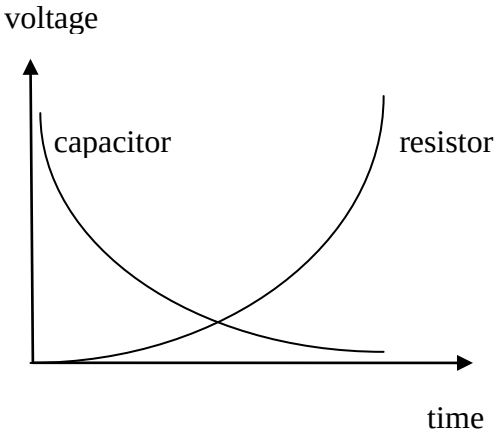
B.



C.



D.



Question 6

Once the capacitor has been fully charged, the switch is **disconnected**. Which one of the following is the closest in value to the time from the moment the switch is disconnected for the voltage across the resistor to be 2.2 V?

A. 0.5 s

B. 1.2 s

C. 2.5 s

D. 3.5 s

Question 7

The resistor and capacitor are now replaced with those of different magnitudes. The new resistor is 10 kΩ and the value of the capacitor is unknown. When the switch and the circuit is connected, it takes 20.0 s to fully charge the capacitor. The capacitance of the unknown capacitor is

A. 100 μF

B. 400 μF

C. 600 μF

D. 800 μF

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The following information relates to Questions 8 to 11.

To operate a device of resistance R_L, Joseph connects a circuit with a resistor, R_1, of value 100 Ω, a 25 μF capacitor, a 6.0 V Zener diode and a 9.0 V (peak) AC power supply, as shown in Figure 4.

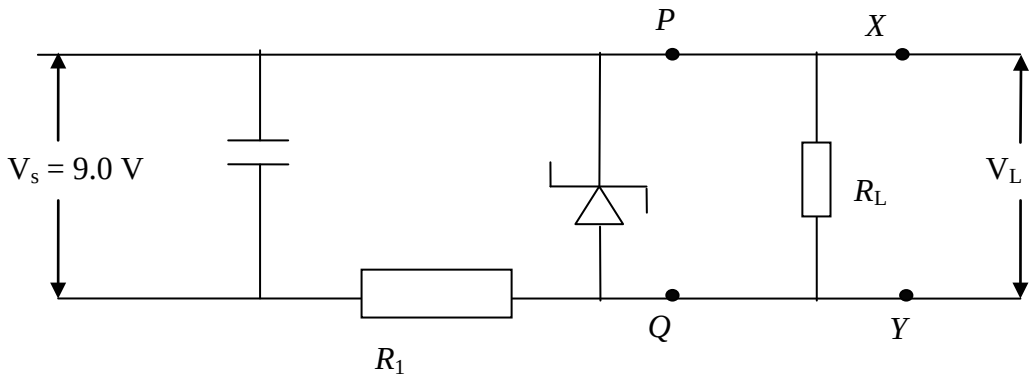

Figure 4

Question 8

Which of the following is closest in value to the current flowing through the resistor R_1?

A. 30 mA

B. 60 mA

C. 120 mA

D. 180 mA

Question 9

The current in the Zener diode is measured as 25 mA. What is the current in the load resistor?

A. 60 mA

B. 35 mA

C. 15 mA

D. 5 mA

Question 10

As the supply voltage reduces from 9.0 V to 8.0 V, which one of the following **best describes** the current in the resistor R_1?

A. The current will rise.

B. The current will reduce.

C. The current will stay the same.

D. No current will flow through the resistor.

Question 11

The capacitor is now replaced with one that has a higher capacitance of 2500 μF. In comparison to the original voltage across points *P* and *Q*, which of the following best describes the new effect on the voltage across *P* and *Q*?

A. More smoothing will occur and the ripple voltage will be higher.

B. There will be no difference from the original voltage.

C. More smoothing will occur and the ripple voltage will be lower.

D. There will be more smoothing, less ripple voltage and the peak voltage will be slightly lower.

The following information relates to Questions 12 and 13.

Two resistors of magnitude 2500 Ω and 7500 Ω are connected to a commercial voltage regulator, as shown in Figure 5. A 12.0 V unregulated power supply is used and the voltage regulator has an output of 9.0 V.

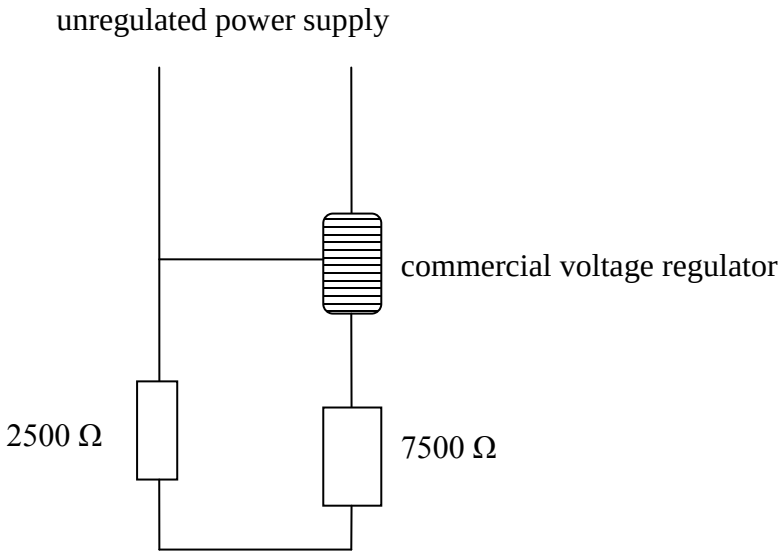

Figure 5

Question 12

The current in the 7500 Ω resistor is about

A. 2.4 mA

B. 1.2 mA

C. 0.9 mA

D. 0.6 mA

Question 13

The power loss in the 2500 Ω resistor is closest in value to

A. 2.0 mW

B. 3.0 mW

C. 5.0 mW

D. 8.0 mW

END OF QUESTION AND ANSWER BOOK