INSIGHT

Trial Exam Paper

2011

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	41
2. Electronics and photonics	11	11	25
B – Detailed Studies			
1. Einstein's special relativity	12	12	24
OR			
2. Materials and their use in structures	12	12	24
OR			
3. Further electronics	12	12	24
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) or pre-written notes (typed or handwritten) and one scientific calculator.
- Students are NOT permitted to bring sheets of 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.
- 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

Instructions for Section A

Answer **all** questions for **both** Areas of study in this section of the paper.
When answer boxes are provided, write your final answer in the box.
If a unit is printed in an answer box, give your final answer in that unit.

Area of study 1 – Motion in one and two dimensions

Use the following information to answer questions 1 and 2.

Figure 1 shows a speed versus time graph for a remote-controlled toy car as it moves on a flat surface in a straight line.

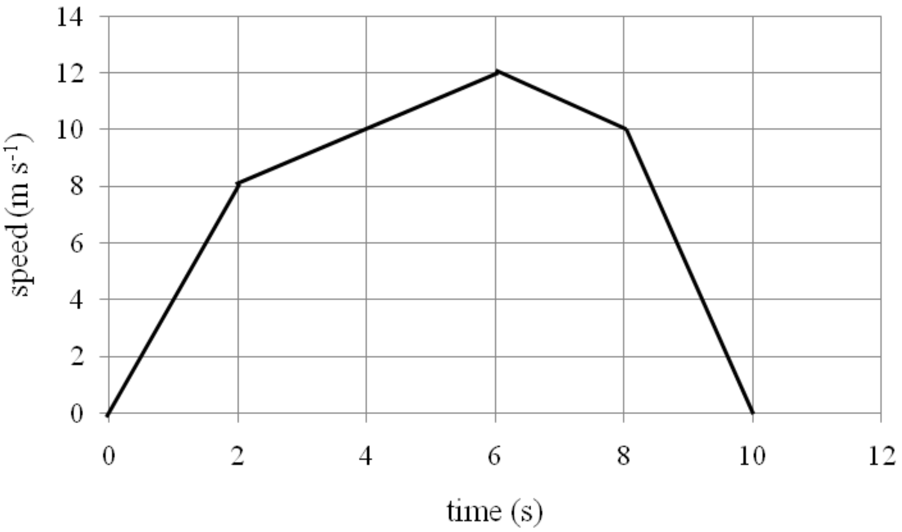

Figure 1

Question 1

Determine the magnitude of the distance travelled by the car in 10 seconds.

m

2 marks

Question 2

Calculate the magnitude of acceleration of the car in the 5th second of its motion.

m s^{-2}

2 marks

Use the following information to answer questions 3–6.

A 4.0 kg cubic block of brass slides from rest on a relatively smooth horizontal floor as it is pulled by a force of 15.0 N acting at an angle of 20°, as shown in Figure 2. There is a constant friction force of 6.0 N acting on the block as it slides forward with uniform acceleration.

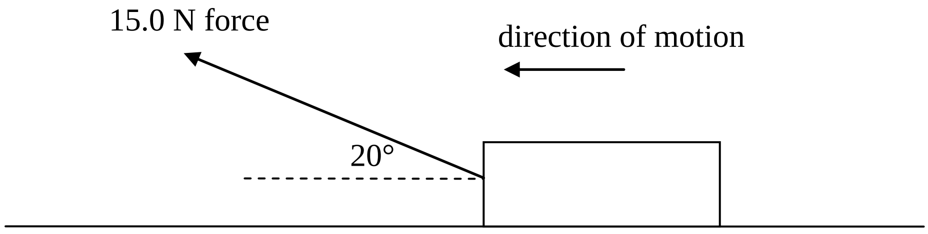

Figure 2

Question 3

Determine the velocity of the block after 3 seconds of motion.

m s^{-1}

3 marks

Question 4

Determine the distance travelled by the block in the time interval from 2.0 s to 4.0 s.

m

2 marks

Question 5

Calculate the work done by the force of 15.0 N on the block as it moves a distance of 2.0 m.

J

2 marks

Question 6

What is the kinetic energy gained by the block as it travels the first 2.0 m from rest?

J

2 marks

Use the following information to answer questions 7–9.

Two trolleys, A and B, of masses 6.0 kg and 3.0 kg, respectively, are initially connected together by a spring and placed on a frictionless air track, as shown in Figure 3. When the connection between the two trolleys is broken suddenly, trolley A is found to move to the left at a constant velocity of 2.0 m s^{-1} and trolley B moves to the right. The direction of motion of each trolley is shown by an arrow in Figure 3. The example can be viewed as an explosion.

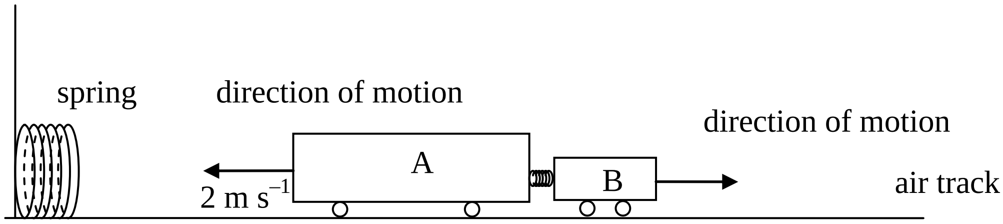

Figure 3

Question 7

Calculate the magnitude of velocity of trolley B just as it moves away from trolley A.

m s^{-1}

2 marks

Question 8

Determine whether the ‘explosion’ of trolleys is an elastic or inelastic process? Explain your answer.

2 marks

Question 9

As trolley A moves to the left, it strikes a spring attached to a wall such that the spring is compressed by 4.0 mm. The trolley comes to an immediate rest, transferring all its energy to the spring. Estimate the spring constant of the spring.

$\mathrm{N\ m^{-1}}$

3 marks

Use the following information to answer questions 10–12.

A 200 g toy aeroplane flies in the air with constant speed and its motion is controlled by a remote device. Figure 4 shows the view from top as the aeroplane makes a horizontal circle in the air, with uniform speed. It makes 10 revolutions in 25 seconds.

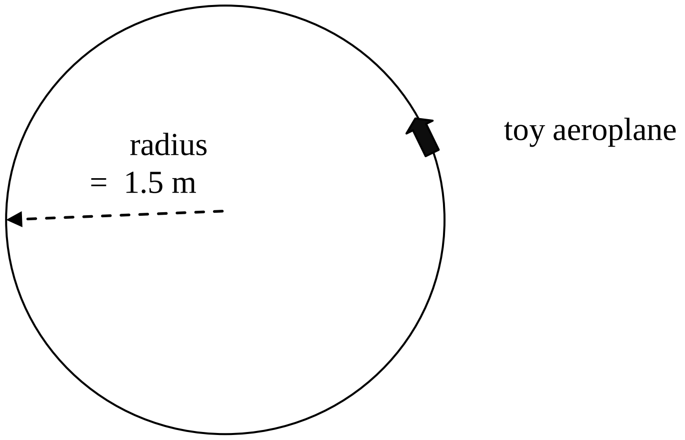

Figure 4

Question 10

Calculate the speed of the aeroplane.

m s^{-1}

2 marks

Question 11

Determine the magnitude of the net force on the aeroplane as it makes the 10 revolutions in 25 seconds at constant speed while making the horizontal circle.

N

2 marks

Question 12

The toy aeroplane now flies in a vertical circle of radius 1.5 m at a constant speed of 5.0 m s^{-1}. Figure 5 shows a side-view of the vertical circle.

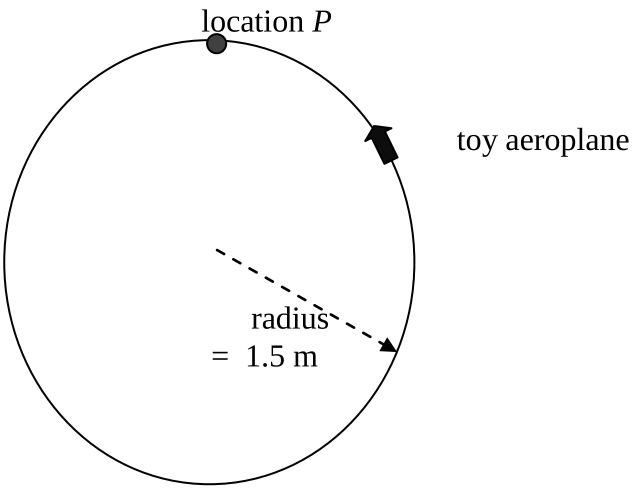

Figure 5

What will be its apparent weight at location *P*, which is the top of the circle? Show your working.

N

2 marks

Use the following information to answer questions 13–15.

A motorcycle stunt rider uses a 30° ramp to launch his motorcycle from a tower of height *h*, as shown in Figure 6, and lands a distance *R* from the base of the tower. Observers measure the rider's launch speed to be 10.0 m s^{-1} and the time of flight to be 1.4 seconds.

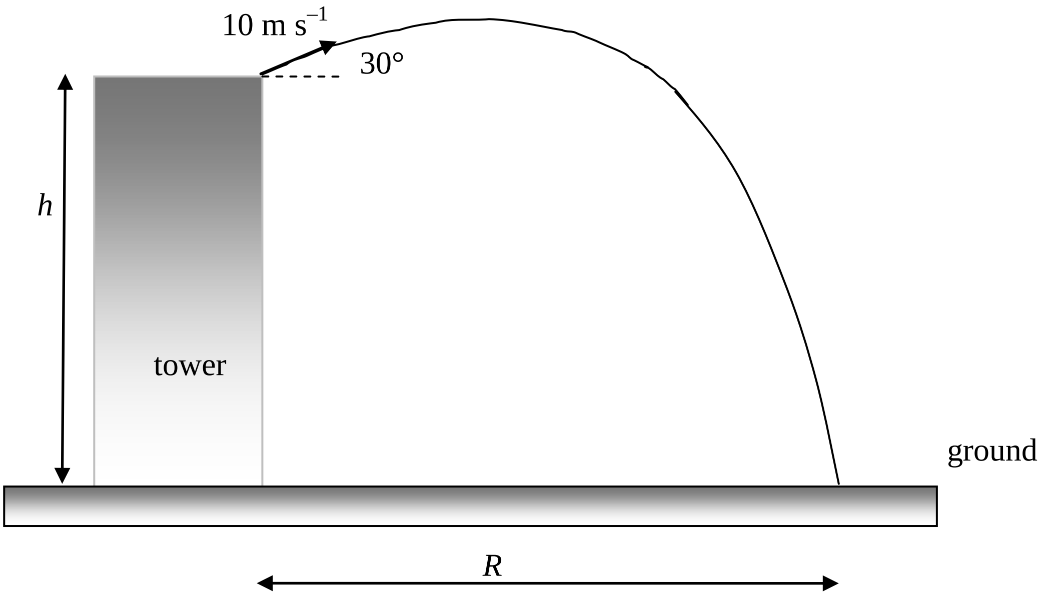

Figure 6

Question 13

Calculate the height, *h*, from which the motorcycle is launched.

m

3 marks

Question 14

What is the distance, *R*, from the base of the tower where the motorcycle lands?

m

2 marks

Question 15

Determine the height above the ground of the motorcycle at a time 0.70 seconds after launch. Show your working clearly.

m

3 marks

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Use the following information to answer questions 16–18.

A spacecraft of total mass 2500 kg is orbiting Earth in a circular orbit with a uniform speed of 7500 m s^{-1}. In the following questions the data below may be needed.

G	6.67×10^{-11} N m^2 kg^{-2}
M_E	5.98×10^{24} kg
R_E	6.37×10^{6} m

Question 16

How high above the surface of Earth is the spacecraft placed? Give your answer in km.

km

3 marks

Question 17

Calculate the gravitational field strength experienced by the satellite due to its proximity to Earth.

N kg^{-1}

2 marks

Question 18

As the spacecraft maintains its uniform circular motion in orbit, a 60 kg astronaut in the spacecraft decides to measure her weight and attaches a spring balance to her feet. What will be the reading of the spring balance? Explain your answer.

N

2 marks

End of Area of study 1
SECTION A – continued
TURN OVER

Area of study 2 – Electronics and photonics

Use the following information to answer questions 1–3.

A 6.0 V DC power supply powers a diode, a 1000 Ω resistor and a variable resistor, *R*, as shown in Figure 1a. The characteristic graph of the diode is shown in Figure 1b. A voltmeter is connected across the 1000 Ω resistor, as shown.

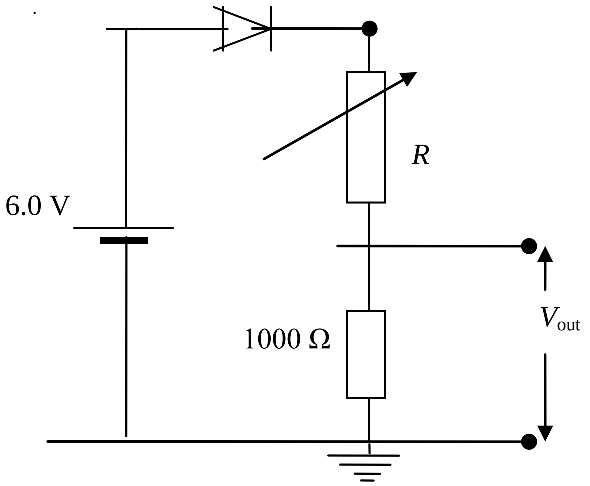


Figure 1a

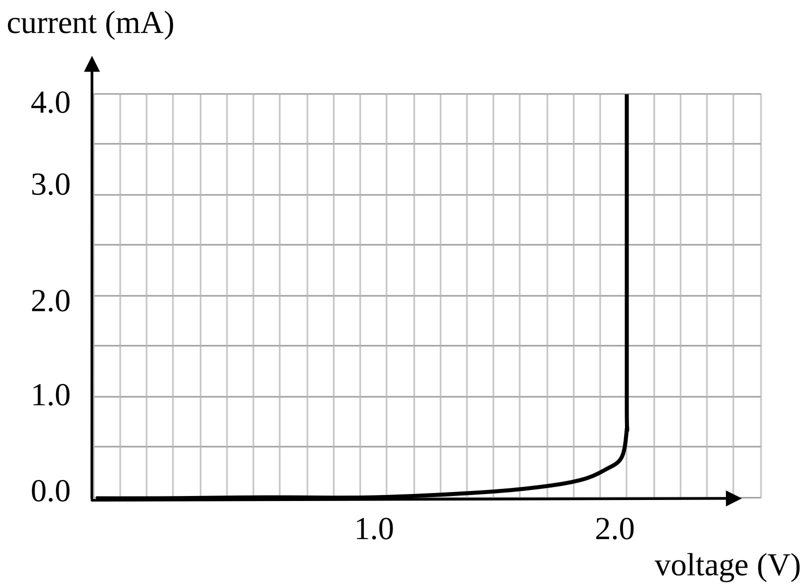


Figure 1b

Question 1

Determine the resistance of the variable resistor when the voltage across the 1000 Ω resistor is 1.0 V.

Ω

2 marks

Question 2

Calculate the current through the variable resistor when the voltage across the 1000 Ω resistor is increased to 2.0 V. Give your answer in mA.

mA

2 marks

Question 3

If the resistance of the variable resistor is reduced, will the voltage across the 1000 Ω resistor increase or decrease? Explain your answer.

___

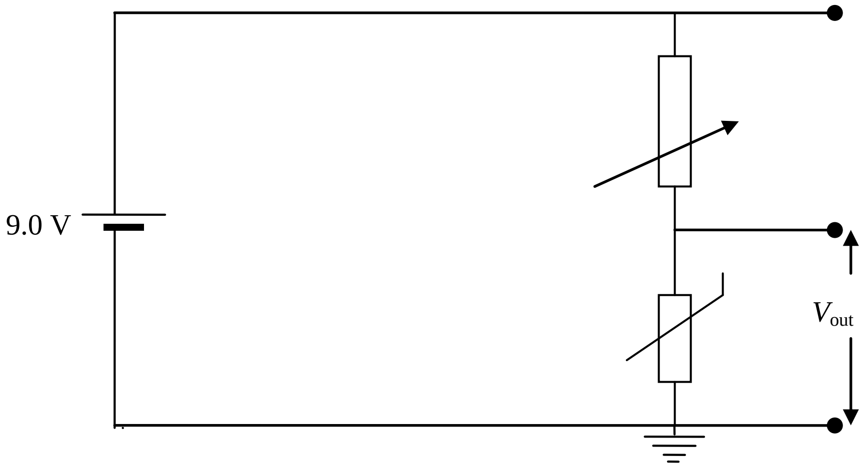
___

___

3 marks

Use the following information to answer questions 4–6.

The temperature in a room is to be maintained below 15°C by use of a cooling system that is controlled by a thermistor. The characteristic graph of the thermistor and the circuit used for it is shown in Figure 2 below.



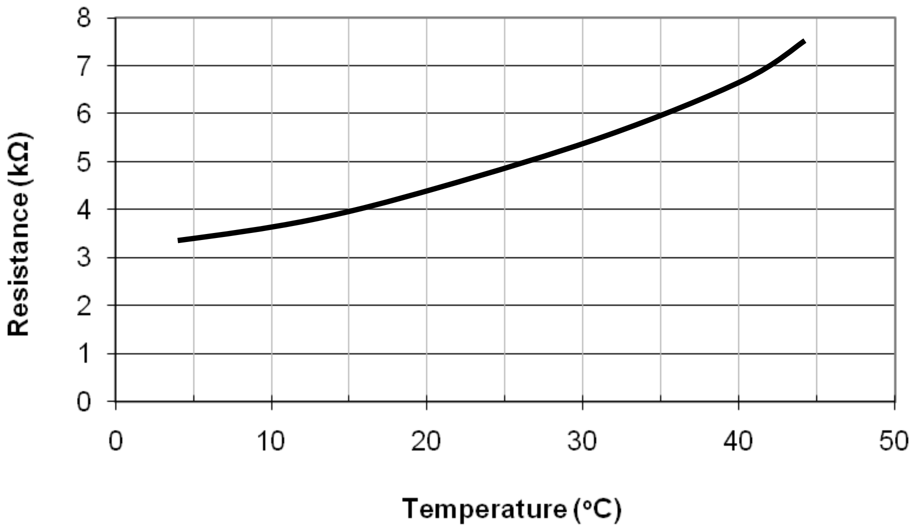


Figure 2

Question 4

What will be the change in temperature of the room for the resistance of the thermistor to increase from 4000 Ω to 6000 Ω?

°C

2 marks

Question 5

The cooler circuit is designed in such a way that the cooler comes on when the temperature is $\geq 15°C$ and the output voltage, V_{out}, is ≥ 3.0 V. At these magnitudes of temperature and voltage output, what will be the value of the variable resistor for the cooler to just come on?

____

____

____

Ω

2 marks

Question 6

Shaun finds that 15°C is too warm for the cooler and wishes the cooler to come on at a lower temperature. Should he have the variable resistor at a higher or a lower resistance for the cooler to switch on, assuming the cooler still switches on at 3.0 V?

____

____

____

3 marks

Use the following information to answer questions 7–9.

The transfer characteristic graph of a transistor amplifier is shown below in Figure 3.

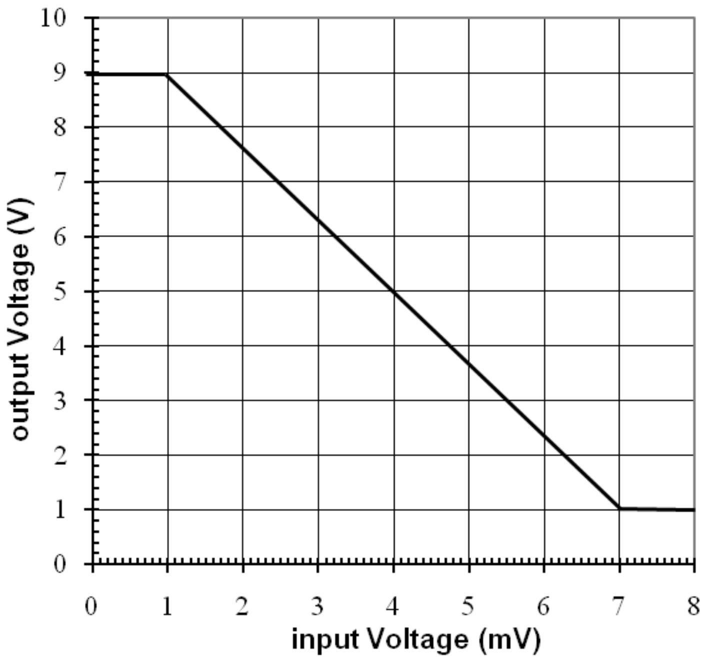


Figure 3

Question 7

Explain whether this amplifier is inverting or non-inverting.

2 marks

Question 8

An AC signal, whose voltage waveform is shown below in Figure 4, is now fed into the amplifier and an undistorted amplified signal is obtained. What is the ideal DC voltage that should be provided to the input signal to avoid distortion? Explain your answer, using the term *bias* in an appropriate manner.

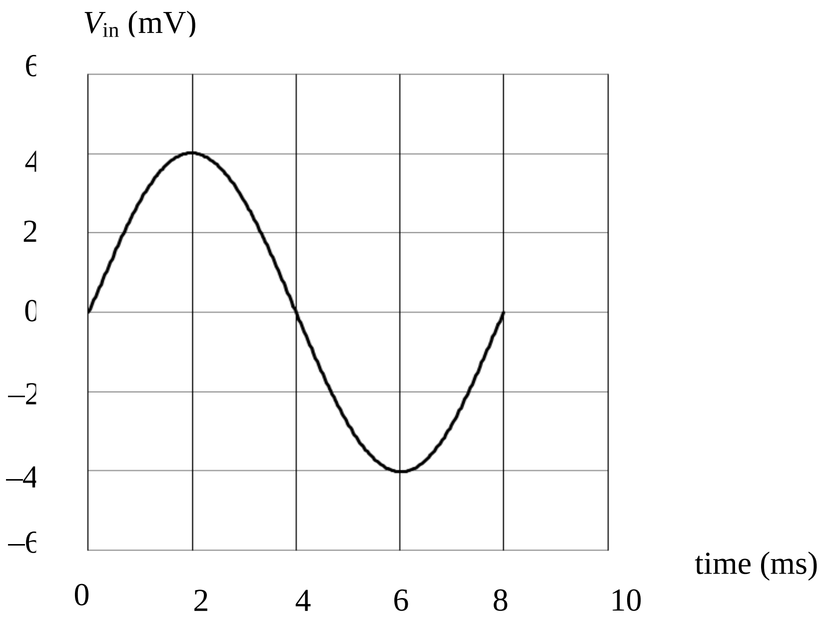


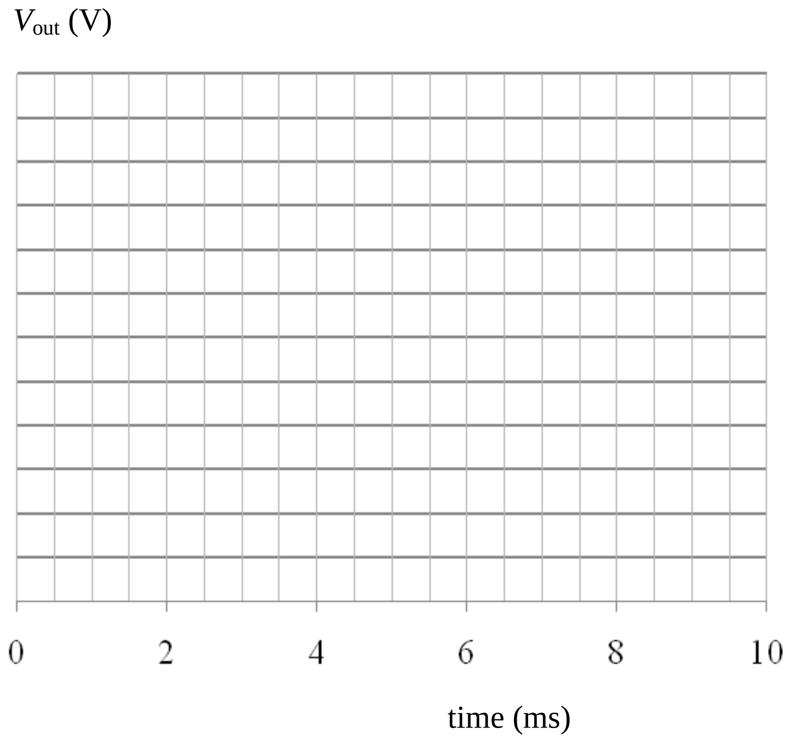
Figure 4

mV

2 marks

Question 9

Provided that the input signal is fed into the amplifier *with appropriate biasing*, sketch the expected output signal on the axes provided below.



3 marks

Use the following information to answer questions 10 and 11.

Figure 5 shows how an audio signal is sent across a fibre optic link to a loudspeaker. It uses an LED, a photodiode and amplifiers to transmit and receive an intensity-modulated signal. Figure 5 also shows the shape of the signal as it emerges from the amplifier and is fed into the LED.

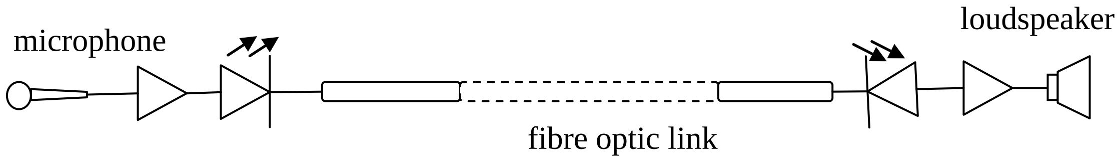


Figure 5

Question 10

Explain what is meant by the term *modulation* in this context.

Modulation ____

____

2 marks

Question 11

Explain whether the photodiode in the circuit should be connected in *forward bias* or *reverse bias*?

____

____

____

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 in the answer boxes provided.

Detailed study 1: Einstein's special relativity

Use the following information to answer questions 1–3.

Michelson and Morley conducted an experiment to study how light waves propagated through *ether*. The experimental set-up was mounted on a rigid stand such that all components of the equipment are still compared to each other. A diagram of the set-up is shown below in Figure 1.

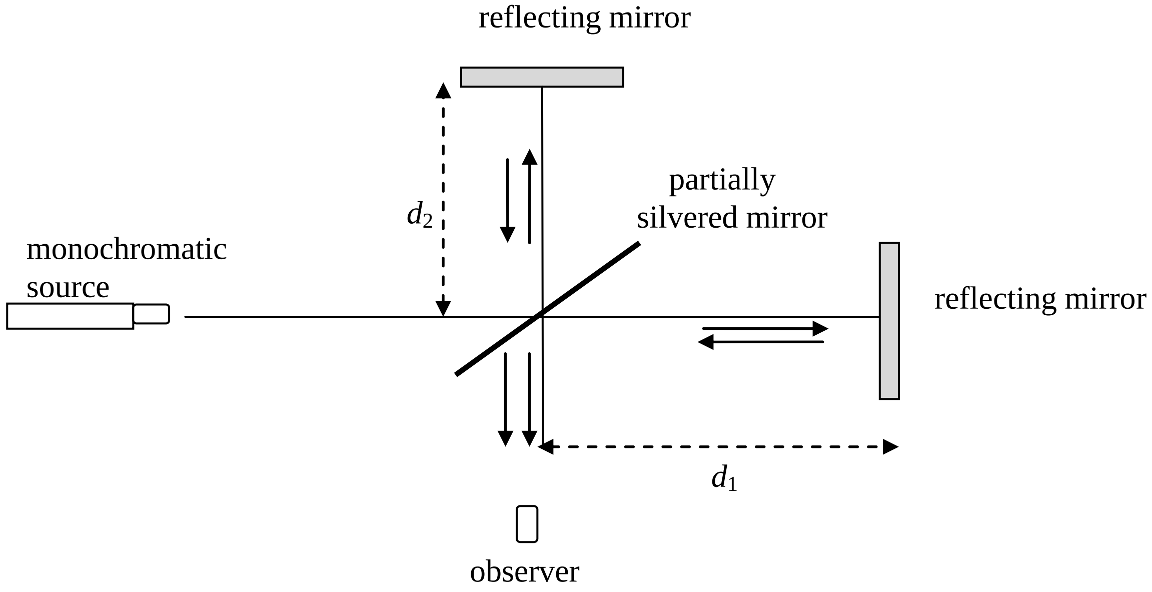


Figure 1

Question 1

Which of the following statements identifies the most important factor in a thorough conduct of the experiment?

A. The partially silvered mirror must transmit 50% of the light and reflect the other 50%.

B. Both reflecting mirrors must reflect 100% of the light.

C. The distances d_1 and d_2 must be equal.

D. The experiment must be carried out only on the equator.

Question 2

The experiment is said to have a 'null' outcome. Which of the following statements best describes the conclusion drawn from this result?

A. Electromagnetic waves do not require a medium to travel.

B. The speed of light is fastest in a vacuum but is not a constant.

C. The speed of light is constant at all times.

D. Light consists of oscillating electric and magnetic fields.

Question 3

Which of the following statements best describes an *inertial reference frame* when compared to the frame of an observer?

A. The two frames are stationary with respect to each other.

B. The frames are moving at constant acceleration with respect to each other.

C. With respect to the observer's frame, the inertial frame is moving with constant acceleration.

D. Inertial reference frames may move at constant speed or be stationary with respect to each other.

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Use the following information to answer questions 4–6.

In a linear accelerator laboratory, electrons are being accelerated by magnetic fields. Scientists measure properties of the electron as it is initially produced with zero speed and then systematically increases its speed close to that of the speed of light.

Question 4

Based on the theory of special relativity, which of the following is the best explanation for why an electron cannot reach the speed of light, c?

A. Electrons do not consist of an electric or magnetic field and, hence, cannot achieve the speeds of electromagnetic waves.

B. Its relativistic mass increases as speed increases, limiting the speed to that of below c.

C. As electrons speed up, they gain kinetic energy but lose radiant energy, so they slow down.

D. In its own reference frame, the electron can reach the speed of light, but to an observer in another reference frame, that speed will always be less than c.

Question 5

In one experiment, the mass of an electron is observed to increase by a factor of 5. The speed at which it must be moving is closest to

A. $0.94c$

B. $0.96c$

C. $0.98c$

D. $0.95c$

Question 6

For the electron in Question **5**, its kinetic energy is best estimated as

A. 1.1×10^{-13} J

B. 8.2×10^{-14} J

C. 9.9×10^{-13} J

D. 3.3×10^{-13} J

Use the following information to answer questions 7–11.

An observer on Earth watches two UFO spaceships, U1 and U2, moving initially with constant speeds of 0.85*c* and 0.55*c*, respectively. At this time the spaceships were moving with constant speed in straight-line paths.

Question 7

When the two spaceships are moving in the same direction, their relative velocity with respect to one another is closest to

A. 0.65*c*
B. 0.56*c*
C. 0.54*c*
D. 0.45*c*

Question 8

When the two spaceships are moving in the opposite directions, their relative velocity with respect to one another is closest to

A. 0.95*c*
B. 0.59*c*
C. 0.89*c*
D. 0.98*c*

Question 9

It is known that spaceship U1 has a length of 30.0 m. When it passes the observer, she would observe the length to be closest to

A. 10.7 m
B. 39.3 m
C. 15.8 m
D. 32.6 m

Question 10

At another time, the spaceship U1 changes its speed. The observer now measures the length of spaceship U1 to be 10.0 m. The speed at which the spaceship must be travelling is best estimated as

A. 0.98*c*
B. 0.94*c*
C. 0.88*c*
D. 0.84*c*

Question 11

A particle of rest mass 8.3×10^{-26} kg is sighted in a research particle accelerator travelling at 0.96*c*, only to disappear the next instant. If the particle has converted to pure energy, then this energy produced is best estimated as

A. 7.5×10^{-9} J
B. 8.4×10^{-9} J
C. 1.2×10^{-8} J
D. 2.6×10^{-8} J

Question 12

Which one of the following statements is postulated by Einstein's special theory of relativity?

A. The measured values of length and time are the same in all inertial reference frames.
B. Newton's three laws of motion are valid in all inertial reference frames.
C. The speed of light is constant in a vacuum when either the source or observer is stationary and can be slower if there is relative motion.
D. Newton's second law of motion will not work in all inertial reference frames.

End of Detailed Study 1
SECTION B – continued
TURN OVER

Detailed study 2: Materials and their use in structures

Use the following information to answer Question 1.

A steel mesh is often used to reinforce a concrete driveway, as shown in Figure 1. The mesh is placed on the ground and concrete placed over it so that the mesh is on the bottom half of the concrete.

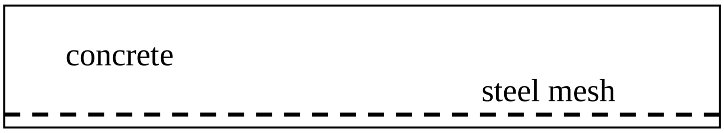

Figure 1

Question 1

Which of the following is the best reason why the steel mesh is placed in this way?

A. Steel is stronger than concrete in compression.

B. Steel is stronger than concrete in tension.

C. Steel will rust if close to the surface.

D. A steel mesh will reduce cracks in the concrete due to natural drying.

Use the following information to answer questions 2 and 3.

Figure 2 shows a beam of length 2.40 m and mass 80.0 kg balanced horizontally at a point labelled *F*. It carries three masses of 10.0 kg, 15.0 kg and 20.0 kg, as shown. The 10.0 kg mass is 0.80 m from the centre and the 15.0 kg mass is 0.90 m from the centre, as shown.

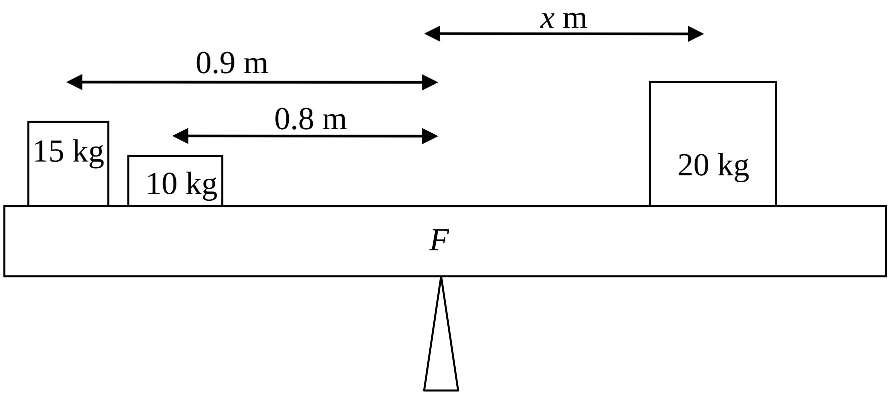

Figure 2

Question 2

The distance from the centre to the mass of 20.0 kg, *x*, is closest to

A. 0.90 m
B. 1.20 m
C. 1.08 m
D. 0.60 m

Question 3

The reaction force at *F*, the point of support, is closest in magnitude to

A. 150 N
B. 250 N
C. 350 N
D. 450 N

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Use the following information to answer questions 4 and 5

Figure 3 shows a picture hanging on a support by two strings and is in equilibrium. The tension in one of the strings is 20 N and it makes an angle of 25° with the horizontal. The other string makes an angle of 30° with the horizontal.

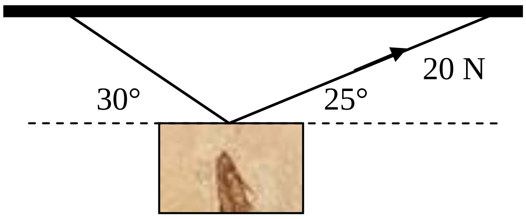

Figure 3

Question 4

The best estimate for the tension in the other string is

A. 22 N

B. 21 N

C. 19 N

D. 18 N

Question 5

The best estimate of the mass of the picture to maintain equilibrium is

A. 1.9 kg

B. 2.5 kg

C. 3.2 kg

D. 4.1 kg

Use the following information to answer questions 6–9.

Figure 4 shows the force–extension (F vs Δx) behaviour to fracture of four different materials under tension. All samples used in the tests are of identical shape and size. The length of each sample is 0.15 m with a cross-sectional area of 5.0×10^{-5} m^2.

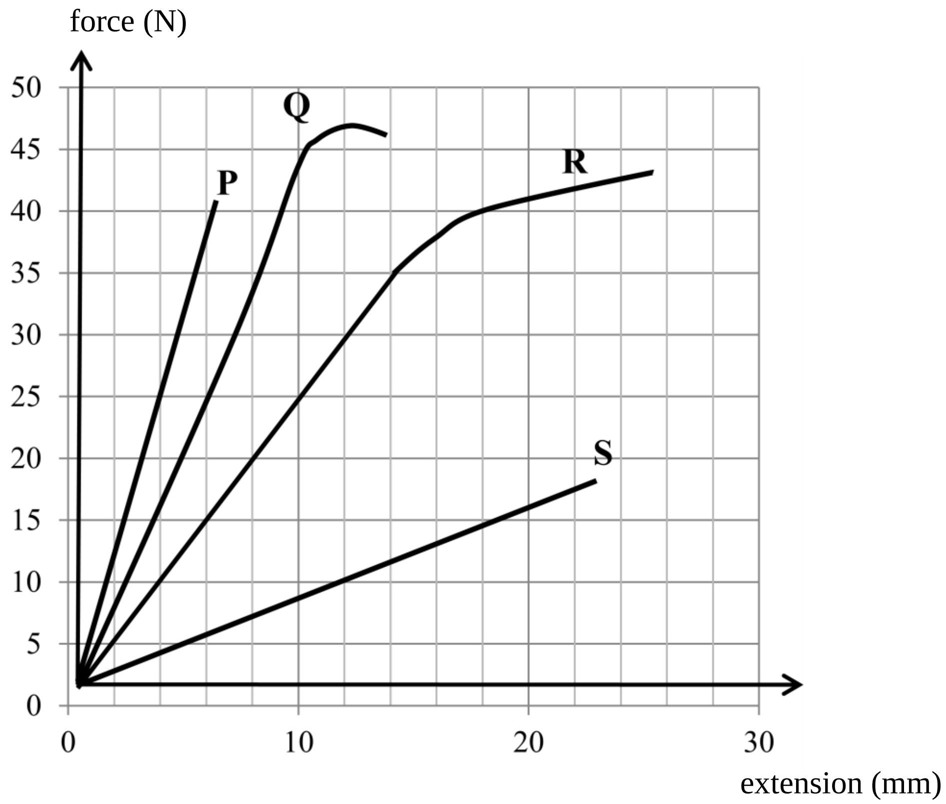

Figure 4

Question 6

Which of the following is the most accurate statement about the toughness of the four materials?

A. Toughness cannot be compared with force–extension graphs.

B. Material R is tougher than material P.

C. Material P is tougher than material Q.

D. Material Q is tougher than material R.

Question 7

Young’s modulus of material S is closest in value to

A. 200 MPa
B. 400 MPa
C. 500 MPa
D. 800 MPa

Question 8

The correct value of the force constant of sample Q is

A. 47 N
B. 450 N m^{-1}
C. 4.5 N m^{-1}
D. 4.5×10^3 N m^{-1}

Question 9

The strain energy per unit volume stored in sample P before fracture is best estimated as

A. 3.2×10^4 J m^{-3}
B. 2.6×10^4 J m^{-3}
C. 2.2×10^4 J m^{-3}
D. 1.6×10^4 J m^{-3}

Question 10

The ratio of the proportionality limit for sample Q to sample R is

A. 2 : 3
B. 3 : 2
C. 9 : 7
D. 11 : 10

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Use the following information to answer questions 11 and 12.

A bridge is made from a uniform concrete beam of mass 2500 kg and length 10.0 m. It is supported on two pillars that exert an upward reaction force of F_A and F_B, as shown in Figure 5 below. When a vehicle of mass M_c kg is stationary on the bridge 2.0 m from the centre of the concrete beam, the reaction force F_B is 19 500 N. Since the beam is uniform, the weight of the concrete beam, W_{beam}, can be considered to act through the centre of the beam.

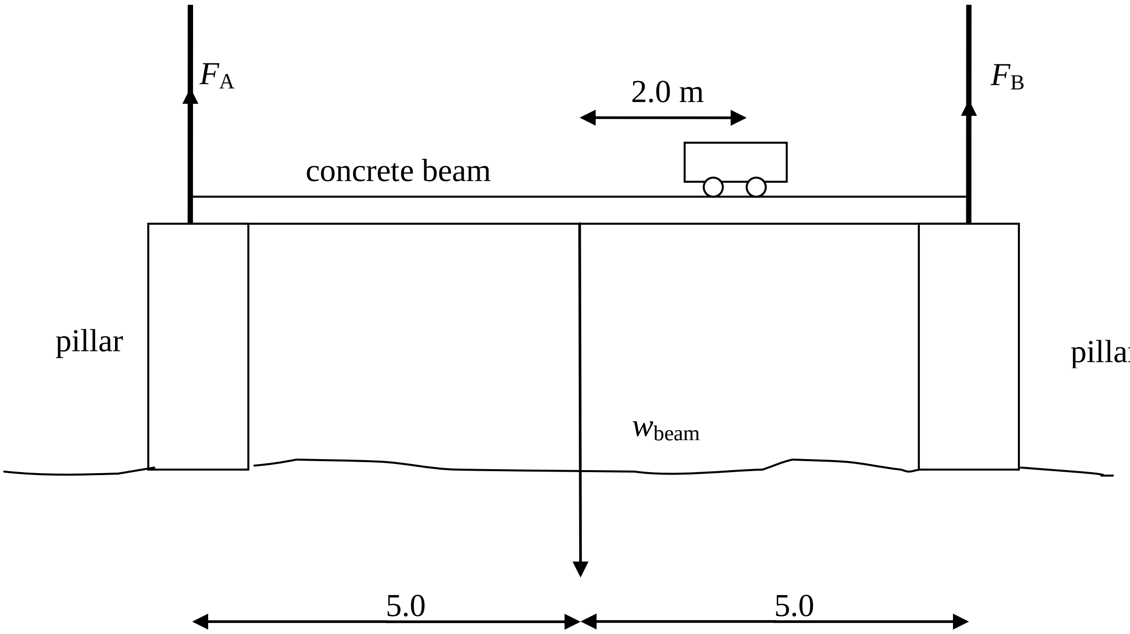

Figure 5

Question 11

The best estimate of the mass, M_c, of the vehicle is

A. 500 kg.
B. 1000 kg.
C. 1500 kg.
D. 2000 kg.

Question 12

The magnitude of the reaction force F_A is closest to

A. 10 500 N
B. 12 000 N
C. 13 500 N
D. 15 500 N

End of Detailed Study 2
SECTION B – continued
TURN OVER

Detailed study 3: Further electronics

Use the following information to answer Questions 1-5

Figure 1a shows an RC circuit consisting of a resistor, 200 μF capacitor, a DC power supply and a switch. The voltage-time behaviour of the resistor and capacitor is measured using a CRO and is shown in Figure 1a.

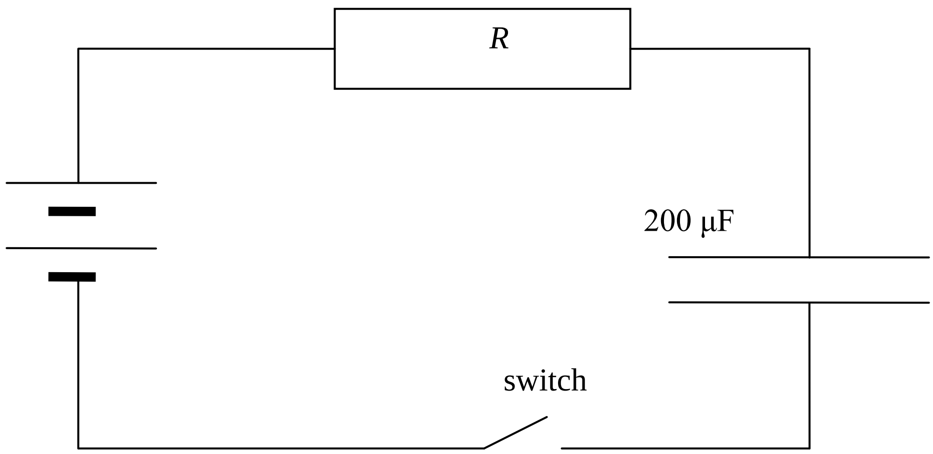

Figure 1a

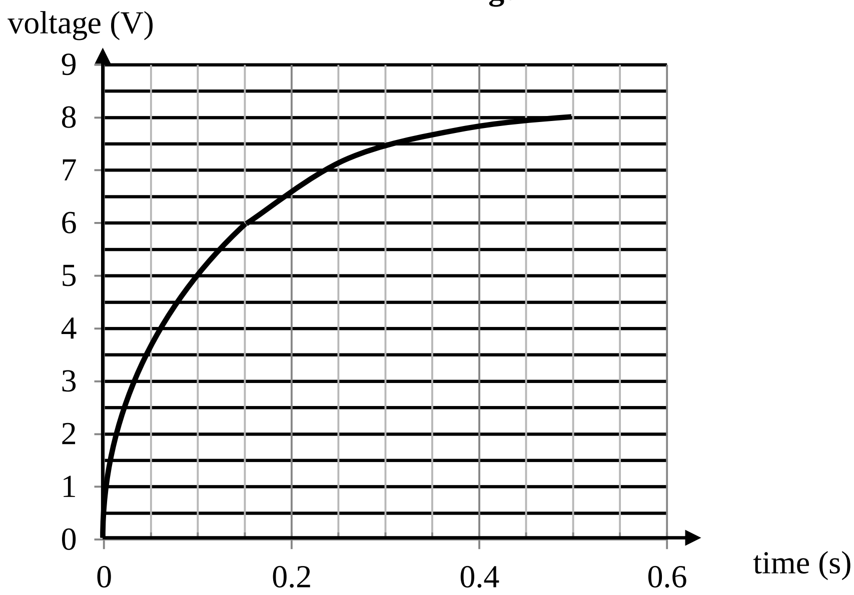

Figure 1b

When the switch is closed, the capacitor charges up and its charging behaviour is shown in Figure 1b.

Question 1

What is the most likely voltage supplied by the battery?

A. 5.0 V
B. 6.0 V
C. 7.0 V
D. 8.0V

Question 2

The best estimate of the voltage drop across the resistor at 0.15 s is

A. 2.0 V
B. 4.0 V
C. 6.0 V
D. 8.0V

Question 3

The value of the resistor is closest to

A. 500 Ω
B. 1000 Ω
C. 1500 Ω
D. 5000 Ω

Question 4

The best value for the charge stored in the capacitor at 0.3 s is

A. 0.5 μC
B. 1.0 mC
C. 1.5 mC
D. 27 μC

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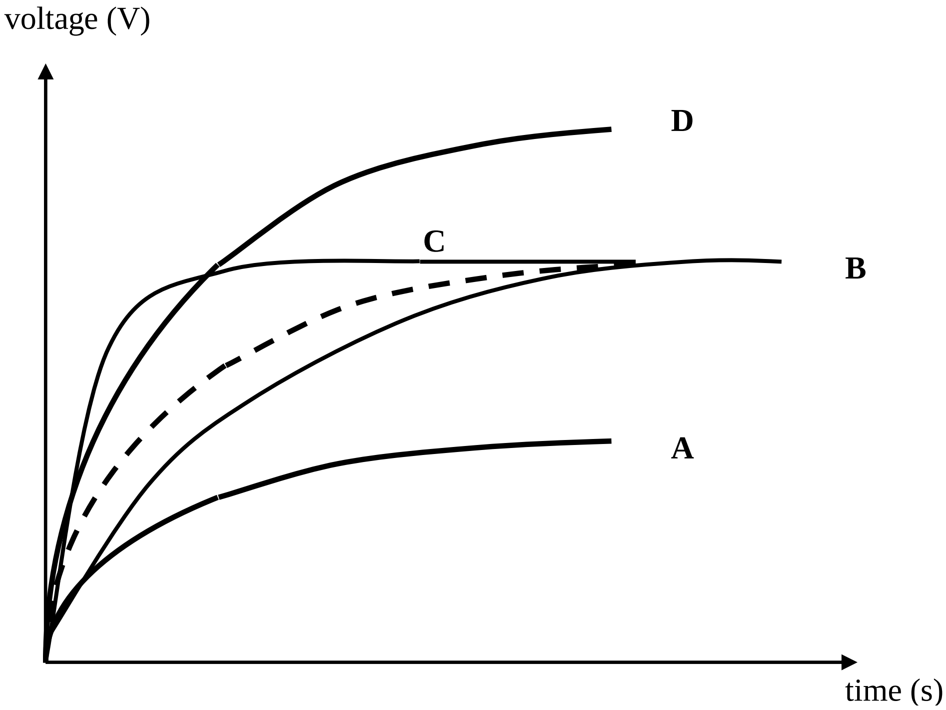
Question 5

Which one of the following is the most likely shape of the capacitor's charging behaviour when the resistor, *R*, is replaced with another resistor of **lower** resistance? For comparison, the original charging behaviour is shown with a dashed line.



Use the following information to answer questions 6–8.

Figure 2a shows a circuit for a DC power supply. It consists of a silicon diode, whose characteristic graph is shown in Figure 2b, a 500 μF capacitor and a 1000 Ω load resistor. A CRO may be connected appropriately at various points, such as to measure the waveforms of input voltage V_{in}, across points *a*–*b* and output voltage V_o.

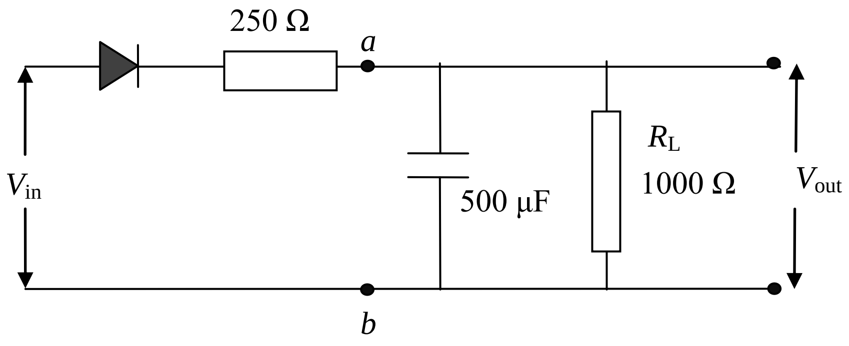


Figure 2a

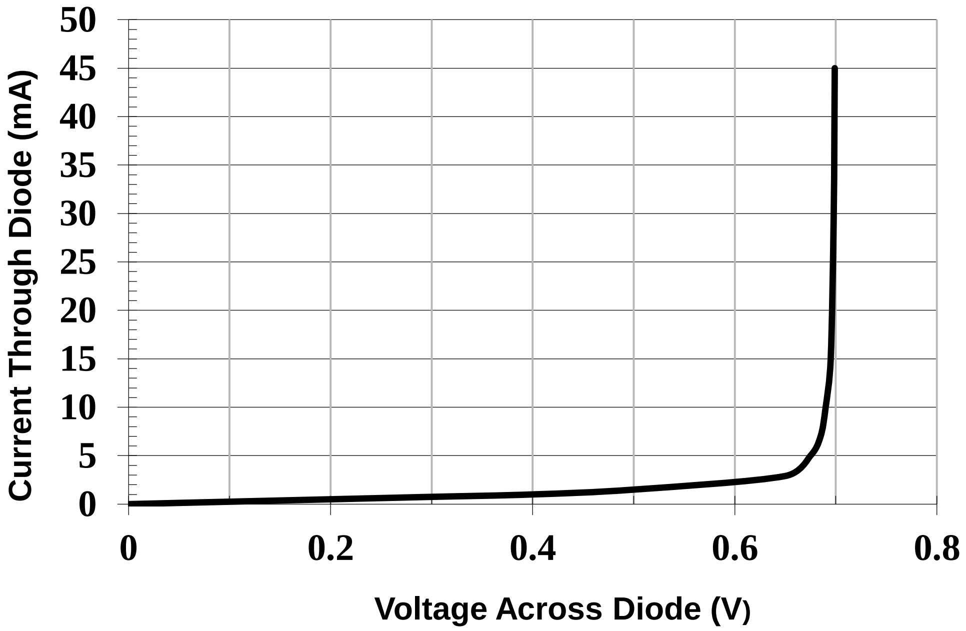


Figure 2b

Question 6

At a certain input voltage waveform, the output voltage recorded by the CRO in position a-b is shown below. The current in the 250 Ω resistor was then 4 mA.

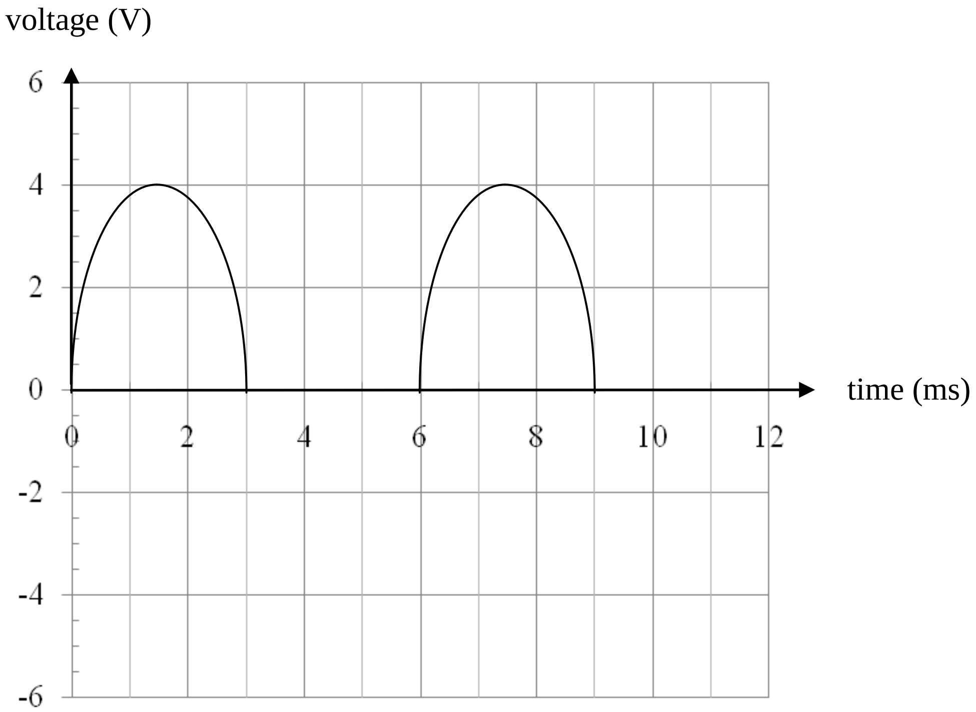


Figure 3

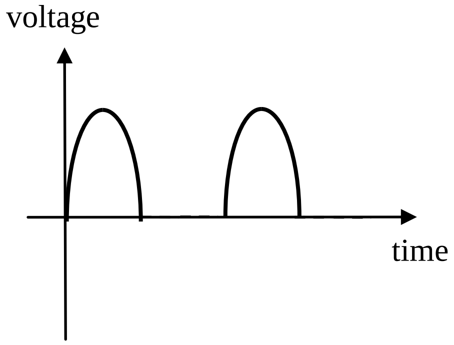
The most likely voltage peak of the input voltage under these conditions is

A. 5.7 V
B. 5.0 V
C. 4.3 V
D. 4.0 V

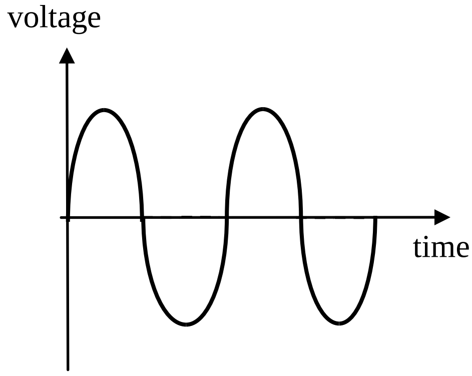
Question 7

If the load resistor is removed from the circuit, the best estimate of the shape of the output voltage waveform is

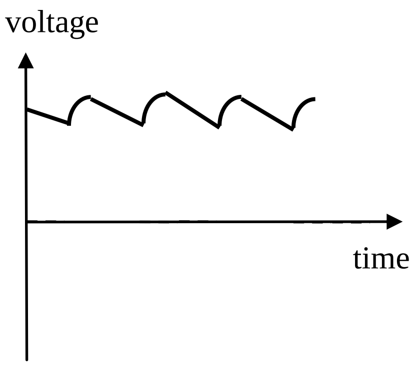
A.



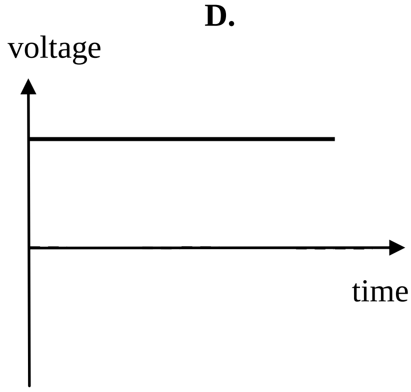
B.



C.



D.



Question 8

A different input voltage is now provided to the circuit shown previously in Figure 2a. The waveform of this new input voltage is shown below in Figure 4.

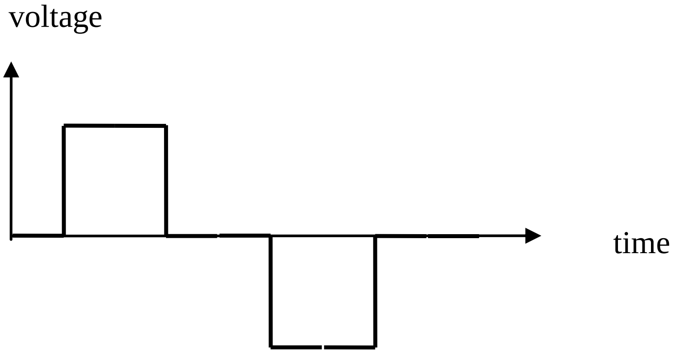
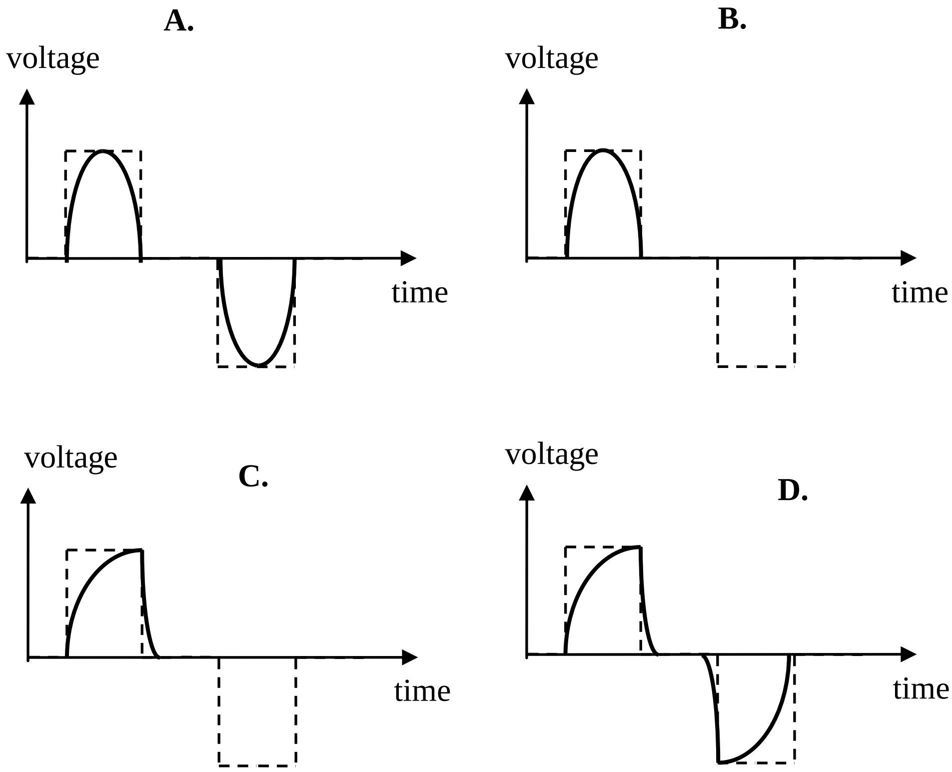


Figure 4

Which one of the following is the most likely shape of the waveform of the output voltage? For comparison, the new input voltage waveform is shown with dashed lines in the figures.



Use the following information to answer questions 9–12.

Figure 5 is an AC to DC regulated voltage power supply, making use of a 100 Ω resistor, a capacitor and a Zener diode. The regulated power is supplied to a 500 Ω load resistor, R_L. The AC supply voltage is 240 V_{RMS} and the voltage supplied to the bridge rectifier is 16 V_{RMS}. The characteristic graph of the Zener diode is also shown in the figure below.

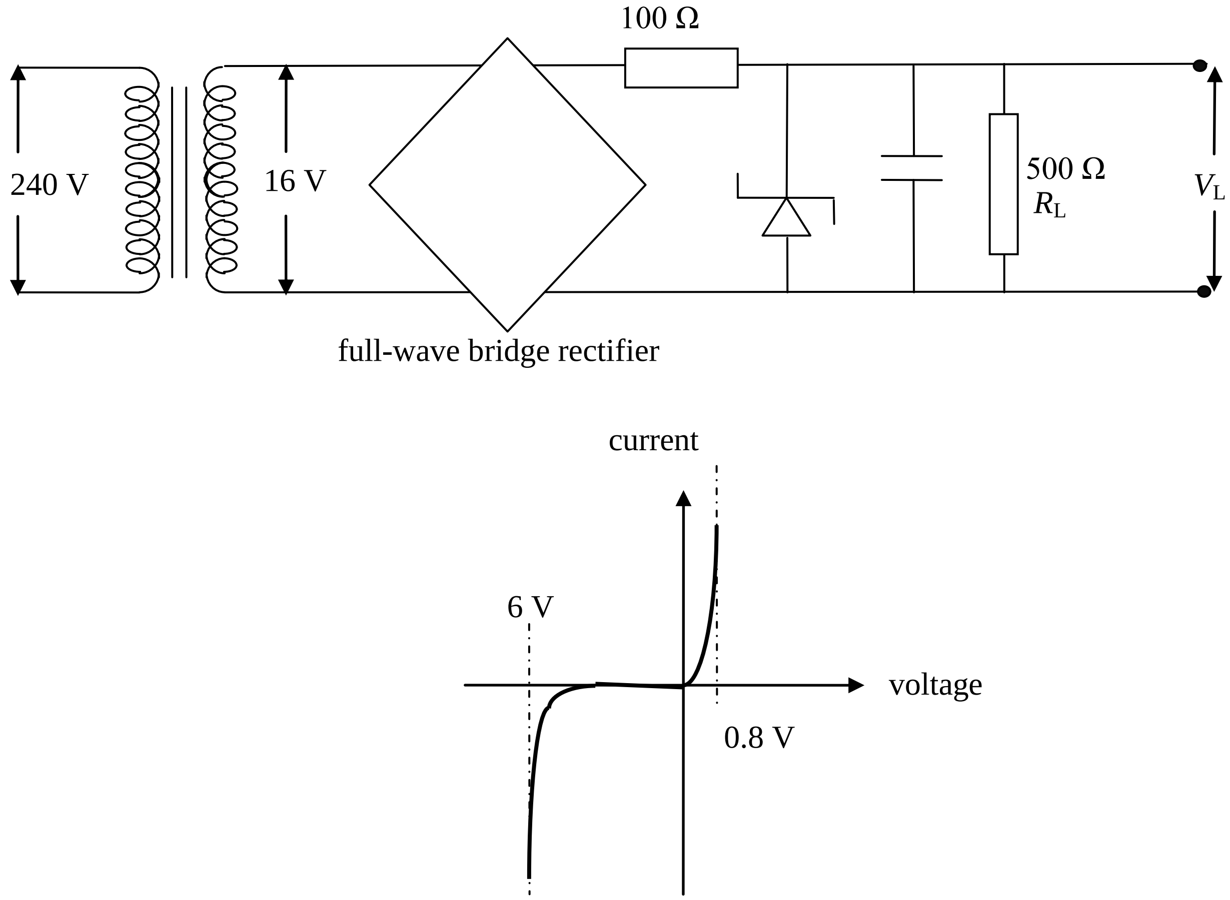


Figure 5

Question 9

What is the correct value of the transformer ratio *number of turns secondary : number of turns primary*?

A. 15 : 1

B. 40 : 1

C. 1 : 15

D. 1 : 40

Question 10

The current in the 100 Ω resistor is 90 mA. The best estimate for the voltage loss in the rectifier is

A. 1.7 V

B. 1.5 V

C. 1.0 V

D. 8.2 V

Question 11

The correct value for the current in the Zener diode is

A. 90 mA

B. 12 mA

C. 102 mA

D. 78 mA

Question 12

The load resistance is now halved. Compared to the current with the initial resistor in place, which one of the following will be the most likely effect on the current through the Zener diode?

A. It will increase by 50%.

B. It will decrease by 50%.

C. It will remain the same.

D. It will decrease by less than 50%.

End of Question and Answer Book