VICTORIAN CURRICULUM AND ASSESSMENT AUTHORITY

Victorian Certificate of Education 2009

SUPERVISOR TO ATTACH PROCESSING LABEL HERE

STUDENT NUMBER

Figures									Letter:
Words									

PHYSICS

Written examination 1

Tuesday 9 June 2009

Reading time: 11.45 am to 12.00 noon (15 minutes)
Writing time: 12.00 noon to 1.30 pm (1 hour 30 minutes)

QUESTION AND ANSWER BOOK

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	14	14	37
2. Electronics and photonics	11	11	27
B – Detailed studies			
1. Einstein's special relativity	13	13	26
OR			
2. Materials and their use in structures	13	13	26
OR			
3. Further electronics	13	13	26
			Total 90

- Students are permitted to bring into the examination room: 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 into the examination room: blank sheets of paper and/or white out liquid/tape.

Materials supplied
- Question and answer book of 42 pages. The question and answer book has a detachable formula sheet in the centrefold.
- Answer sheet for multiple-choice questions.

Instructions
- Detach the formula sheet from the centre of this book during reading time.
- Write your **student number** in the space provided above on this page.
- Check that your **name** and **student number** as printed on your answer sheet for multiple-choice questions are correct, **and** sign your name in the space provided to verify this.
- Unless otherwise indicated, the diagrams in this book are **not** drawn to scale.
- All written responses must be in English.

At the end of the examination
- Place the answer sheet for multiple-choice questions 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.

SECTION A

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.

Areas of study **Page**

Area of study 1 – Motion in one and two dimensions

The following information relates to Questions 1 and 2.

Ranjiv, who has a mass of 80 kg, is running with a speed of 4.0 m s^{-1} as he steps onto a stationary trolley of mass 40 kg as shown in Figure 1. Ranjiv holds on to the trolley. Ranjiv and the trolley then move forward together in the same direction.

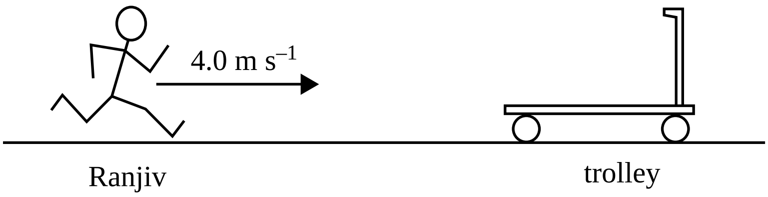


Figure 1

Question 1

What is the speed of the trolley as soon as Ranjiv is on board?

m s^{-1}

2 marks

Question 2

Is this collision between Ranjiv and the trolley elastic or inelastic? Write your answer in the box provided, **and** justify it with a calculation.

3 marks

The following information relates to Questions 3 and 4.

A motorcyclist is riding around a circle of radius of 100 m. The surface is flat and horizontal. The motorcyclist is travelling at a constant speed of 32.0 m s^{-1}. The motorcycle with rider has a mass of 250 kg.

Question 3

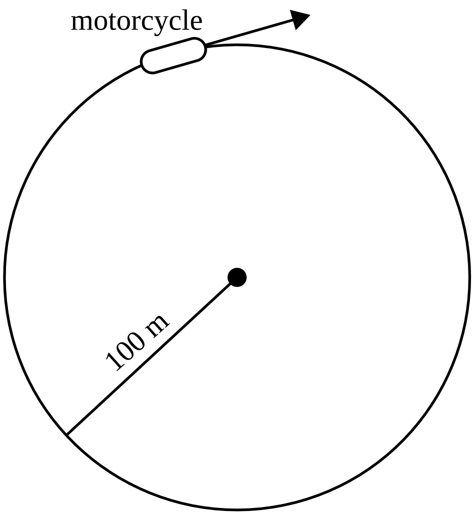
What is the magnitude of the net force on the motorcycle with rider?

N

2 marks

Question 4

Draw an arrow to show the direction of the net force on the motorcycle.



2 marks

The following information relates to Questions 5 and 6.

A block of mass 0.20 kg is held at point A against a spring which has been compressed by 10 cm as shown in Figure 2.

The block is released, and is pushed by the spring across a smooth surface. When the block leaves contact with the spring at point B the block has a speed of 5.0 m s^{-1}.

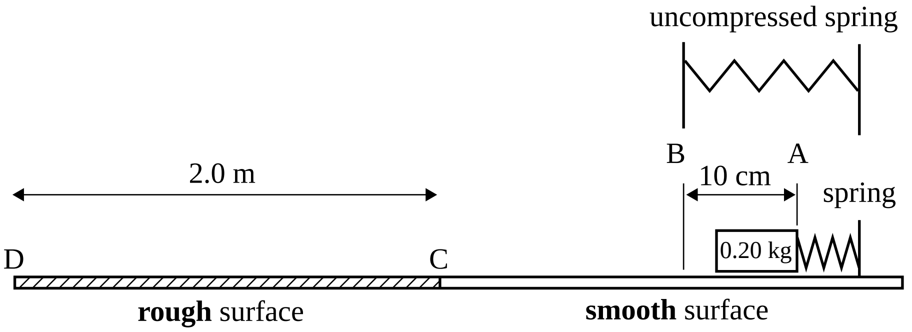


Figure 2

Question 5

What is the spring constant, *k*, of the spring?

N m^{-1}

2 marks

Question 6

At point C the block still has a speed of 5.0 m s^{-1}. At point C the block encounters a rough surface that provides a constant friction force that brings it to rest at point D. The distance C to D is 2.0 m.

What is the magnitude of the friction force?

N

2 marks

The following information relates to Questions 7–9.

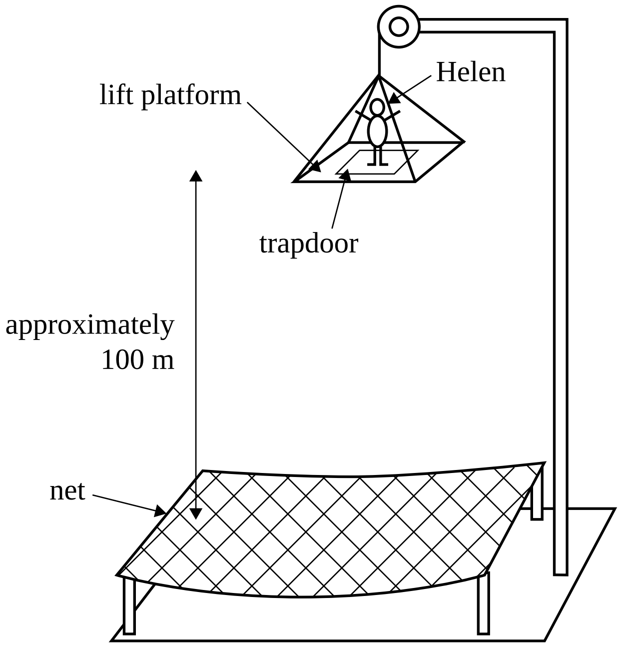


Figure 3

A ride in an amusement park allows a person to free fall without any form of attachment. A person on this ride is carried up on a platform to the top. At the top, a trapdoor in the platform opens and the person free falls. Approximately 100 m below the release point, a net catches the person.

A diagram of the ride is shown in Figure 3.

Helen, who has a mass of 60 kg, decides to take the ride and takes the platform to the top.

The platform travels vertically upward at a constant speed of 5.0 m s^{-1}.

Question 7

What is Helen's apparent weight as she travels up?

N

2 marks

As the platform approaches the top, it slows to a stop at a uniform rate of 2.0 m s^{-2}.

Question 8

What is Helen's apparent weight as the platform slows to a stop?

N

3 marks

Helen next drops through the trapdoor and free falls. Ignore air resistance.

During her fall, Helen experiences 'apparent weightlessness'.

Question 9

In the space below explain what is meant by apparent weightlessness. You should make mention of gravitational weight force and normal or reaction force.

4 marks

The following information relates to Questions 10 and 11.

Max hits a ball from the edge of a cliff. The ball has an initial speed of 60 m s^{-1} at an angle of 30° to the horizontal as shown in Figure 4. Ignore the effects of air resistance.

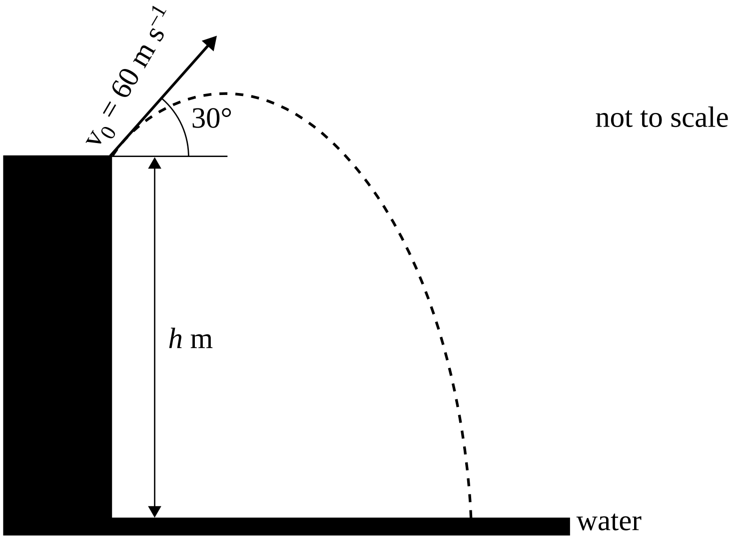


Figure 4

Question 10

How high above the top of the cliff does the ball rise?

m

4 marks

Question 11

The ball takes 9.0 s from the time Max hits it until it lands in the water. What is the height, *h*, of the cliff?

m

3 marks

Question 12

On a loop-the-loop roller coaster, a loop in the track has a radius of 7.0 m as shown in Figure 5.
On a particular occasion, the mass of the trolley and riders is 600 kg.

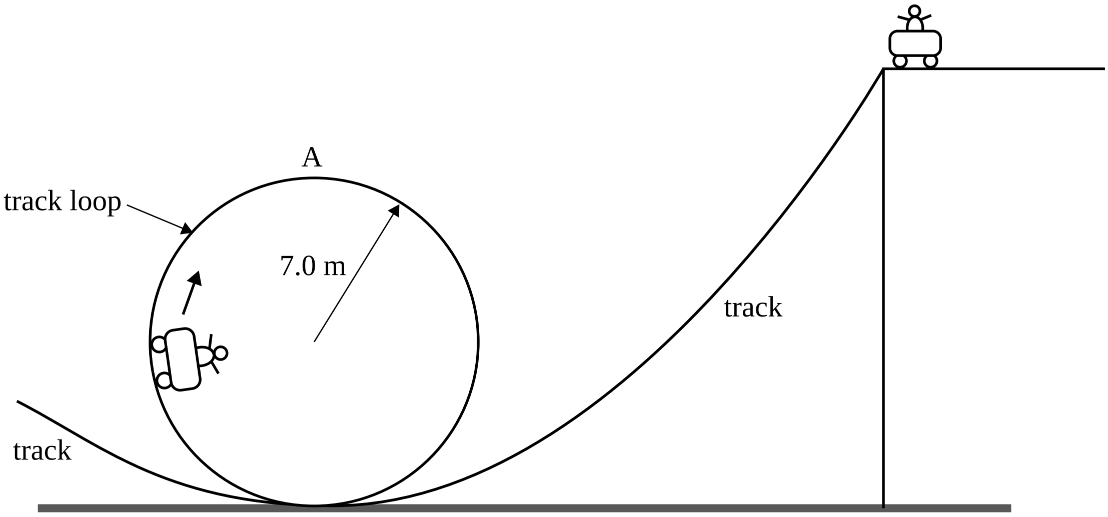


Figure 5

To go safely around the loop, the trolley wheels must not leave the rails at point A.
What is the minimum speed that the trolley must have at point A so that it does not leave the rails?

m s^{-1}

3 marks

The following information relates to Questions 13 and 14.

The **Jason 2** satellite reached its operational circular orbit of radius 1.33×10^7 m on 4 July 2008 and then began mapping the Earth's oceans.

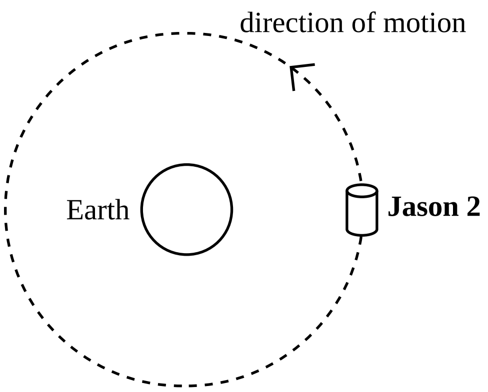
mass of the Earth = 5.98×10^{24} kg

mass of **Jason 2** = 525 kg

$G = 6.67 \times 10^{-11}$ N m^2 kg^{-2}

Question 13

On the figure below, draw one or more labelled arrows to show the direction of any force(s) acting on **Jason 2** as it orbits Earth. You can ignore the effect of any astronomical bodies other than the Earth.



2 marks

Question 14

What is the period of orbit of the **Jason 2** satellite?

s

3 marks

END OF AREA OF STUDY 1

SECTION A – continued

Area of study 2 – Electronics and photonics

The following information relates to Questions 1–3.

Janelle sets up the circuit shown in Figure 1. The circuit consists of a 10 V battery and two resistors, R_1 = 40 Ω and R_2 = 30 Ω.

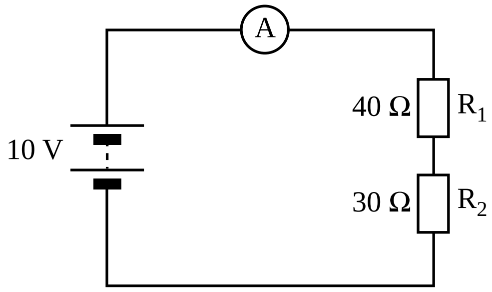


Figure 1

Question 1

What is the potential difference (voltage drop) across R_2?

V

2 marks

Question 2

What is the power dissipated in R_1?

W

3 marks

Janelle now adds a third resistor, R_3 = 20 Ω, as shown in Figure 2.

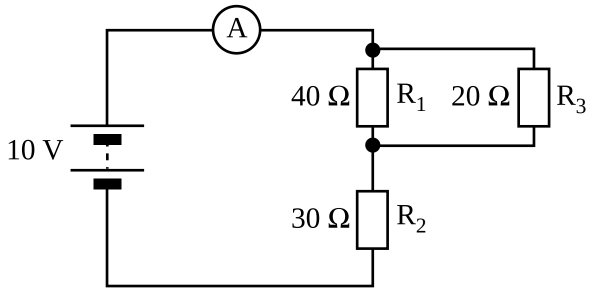


Figure 2

Question 3

What is the current through the ammeter A now?

A

3 marks

The following information relates to Questions 4 and 5.

Richard is conducting experiments with a number of identical Light Emitting Diodes (LEDs).

The I–V characteristics of these diodes are shown in Figure 3.

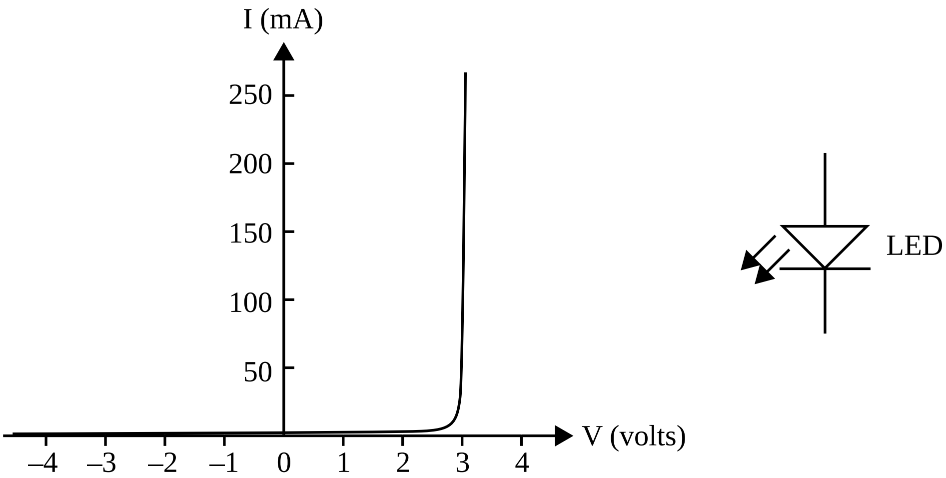


Figure 3

Question 4

Richard sets up a circuit involving 6 identical LEDs as shown in Figure 4.

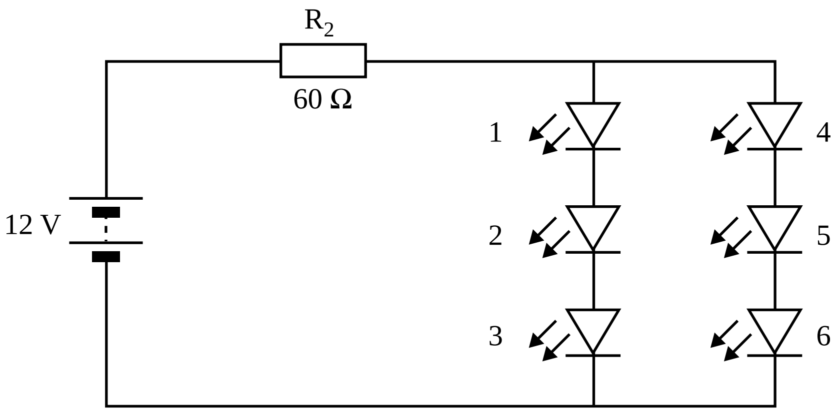


Figure 4

What is the value of the current through R_2?

A

3 marks

Question 5

Later, Richard sets up the same circuit again but makes a mistake and connects LED 2 reversed, as shown in Figure 5.

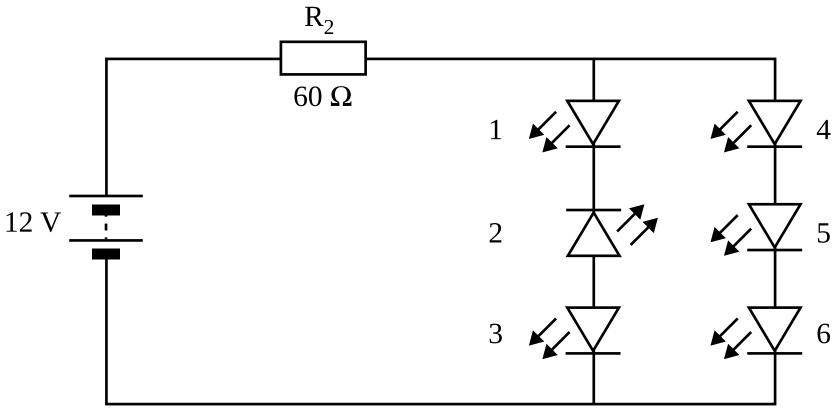


Figure 5

By writing ON or OFF in the appropriate boxes in the table below, indicate which of the six LEDs are ON and which are OFF.

LED	1	2	3	4	5	6
ON or OFF						

2 marks

The following information relates to Questions 6 and 7.

The characteristics of an amplifier are shown in Figure 6.

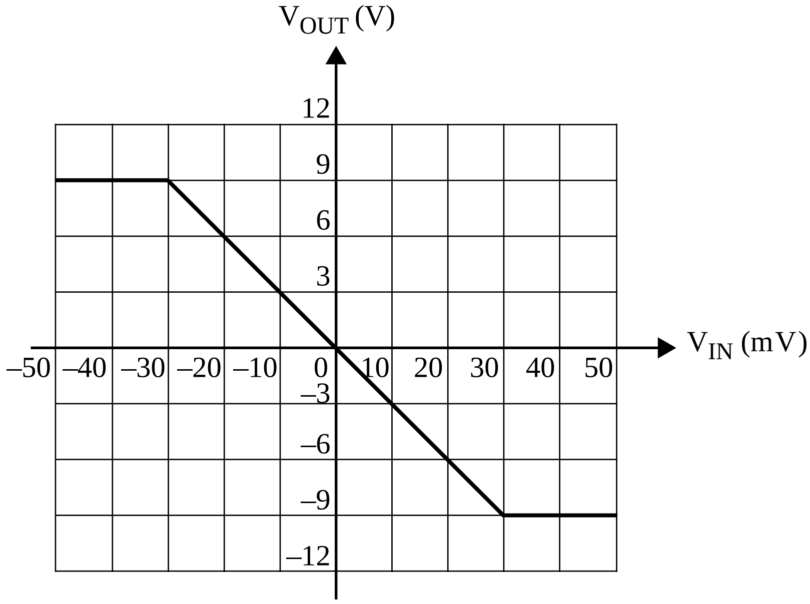


Figure 6

Question 6

What is the voltage gain of the amplifier in the linear region (input up to ±30 mV)?

2 marks

Question 7

The input signal to the amplifier is shown in Figure 7 below.

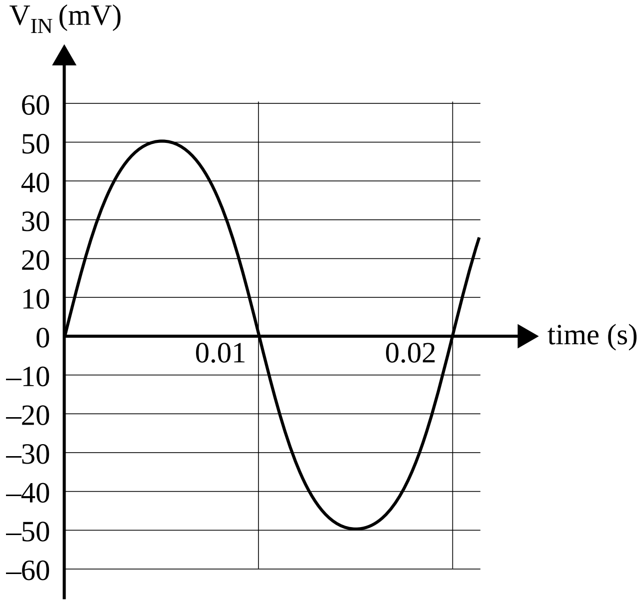
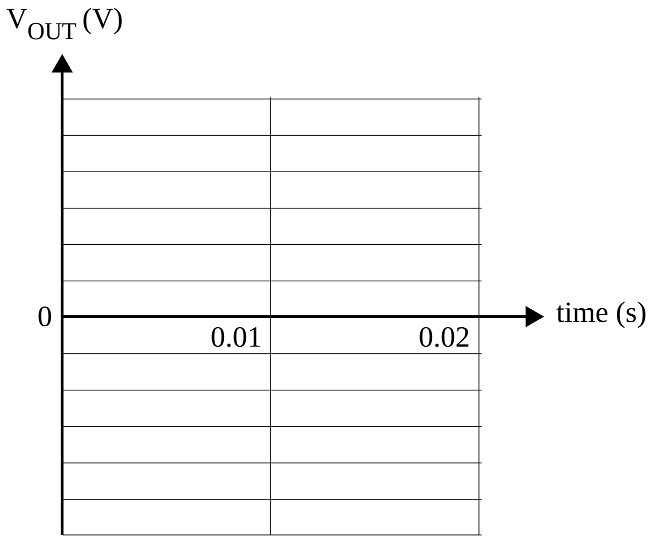


Figure 7

On the axes provided below, sketch the output signal of the amplifier (V_{OUT}) and assign a scale to the vertical axis.



3 marks

In certain large concert venues, it is common to use a modulated radio signal to link the sound from the microphone of the performer on stage to the audio amplifier system for the venue.

Figure 8 is a schematic diagram for such a modulation/demodulation system.

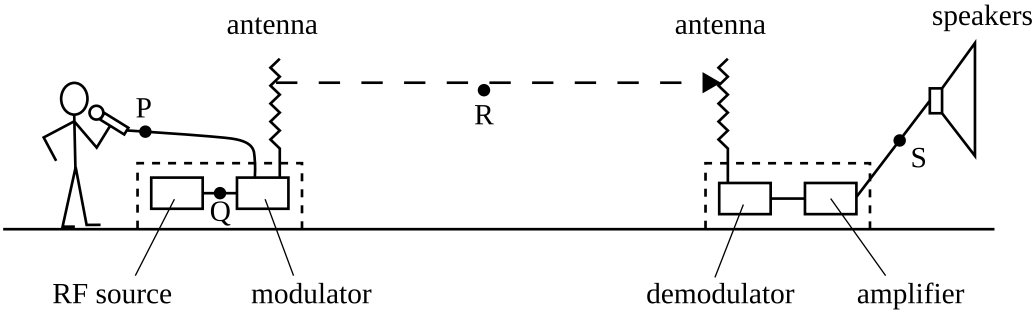


Figure 8

Figure 9 shows three signals, A, B and C, that might be observed at locations P, Q, R or S in Figure 8.

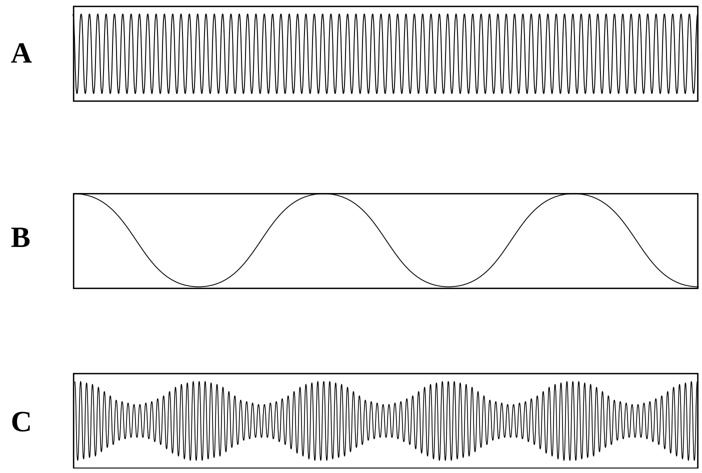


Figure 9

Question 8

In the table below write which of A, B or C best gives the shape of the signal that would be observed at each of the locations P, Q, R and S.

Location	Signal
P	
Q	
R	
S	

2 marks

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The following information relates to Questions 9–11.

The temperature-resistance characteristics of a thermistor are shown in Figure 10.

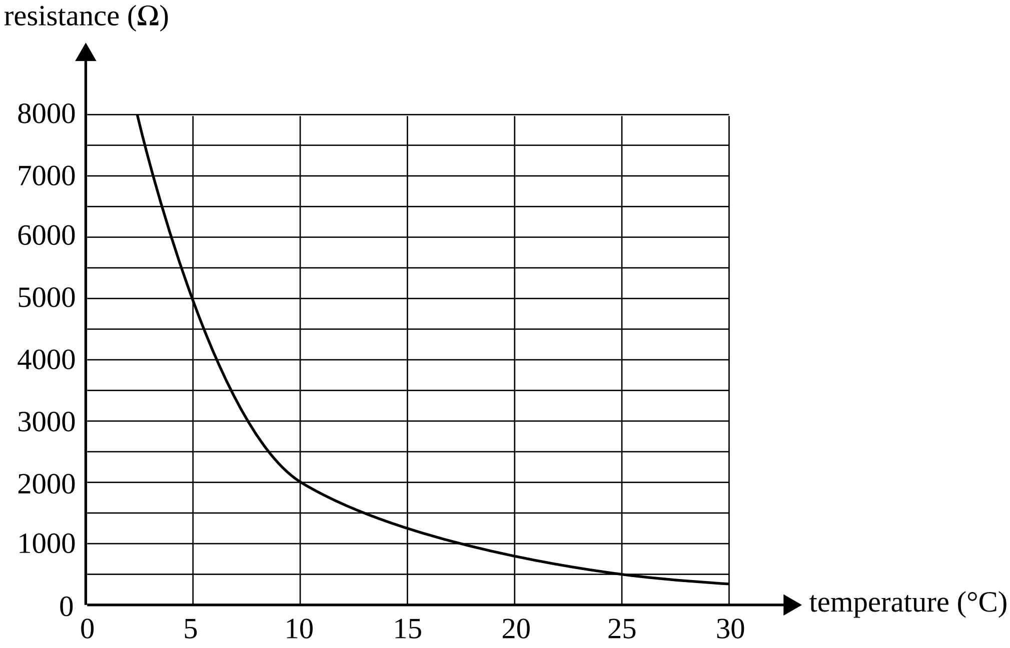


Figure 10

Question 9

What is the resistance of the thermistor when the temperature is 5°C?

Ω

1 mark

The thermistor is incorporated into a circuit to control an air conditioner. The circuit is shown in Figure 11.

The electronic switch activates the air conditioner ON when the voltage across the input of the switch reaches 8 V, and switches OFF when the voltage falls below 8 V.

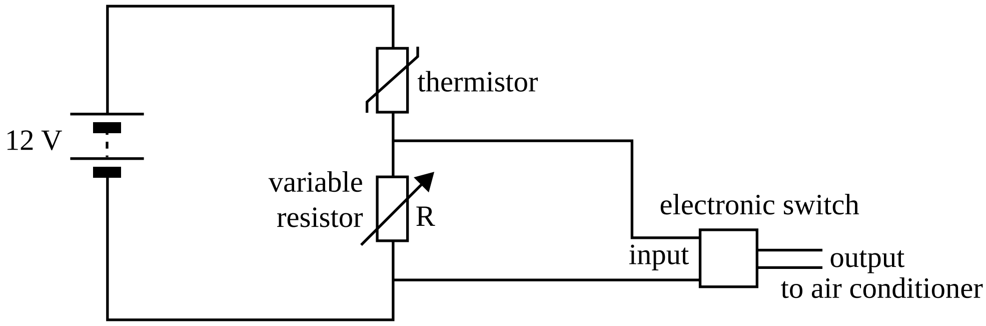


Figure 11

Question 10

The air conditioner needs to come on when the temperature rises to 25°C. What resistance should the variable resistor R be?

Ω

3 marks

Question 11

The air conditioner now needs to come on at a lower temperature.

Should the variable resistor R be increased or decreased to achieve this?

Write increased or decreased in the box provided. You must explain your answer.

3 marks

END OF SECTION A
TURN OVER

SECTION B

Instructions for Section B

Select **one** Detailed study.

Answer **all** questions from the Detailed study, in pencil, on the answer sheet provided for multiple-choice questions.

Write the name of your chosen Detailed study on the multiple-choice answer sheet **and** shade the matching box.

Choose the response that is **correct** or that **best answers** the question.

A correct answer scores 2, an incorrect answer scores 0.

Marks will **not** be deducted for incorrect answers.

No marks will be given if more than one answer is completed for any question.

You should take the value of g to be 10 m s^{-2}.

Detailed study **Page**

Detailed study 1 – Einstein's special relativity

Question 1

Two spaceships, **Discovery** and **Enterprise**, are both travelling relative to an inertial frame of reference at 0.8 *c* in the same direction. Spaceship **Discovery** shines a light beam forward towards **Enterprise** as shown.

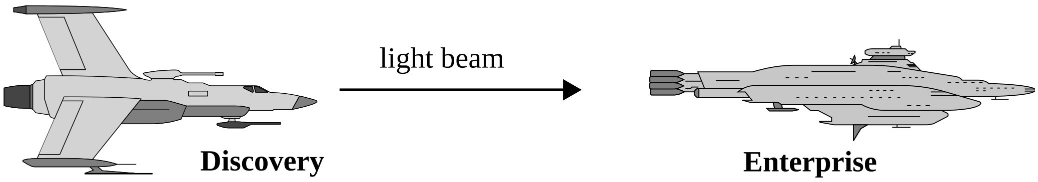


Figure 1

What is the speed of the light beam according to the captain on spaceship **Enterprise**?

A. 0.2 *c*

B. 0.8 *c*

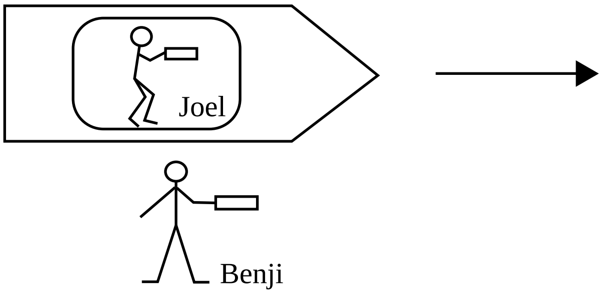
C. *c*

D. 1.8 *c*

The following information relates to Questions 2–4.

Astronaut Benji is floating freely in space when Joel's spaceship passes him at high speed. Benji is holding a ruler, and can see through the window of the spaceship that Joel is also holding a ruler. The two rulers are parallel to the direction of motion of the spaceship.

Both Benji and Joel measure the length of their own ruler to be 1.0 m. Each can see the other ruler. Benji observes Joel's ruler to be 0.6 m long.



Question 2

Which one of the following gives the length of Benji's ruler as observed by Joel?

A. 0.6 m
B. 1.0 m
C. 1.4 m
D. 1.7 m

Question 3

Which one of the following gives the proper length of Joel's ruler?

A. 0.6 m
B. 1.0 m
C. 1.4 m
D. 1.6 m

Question 4

Which one of the following gives the speed of Joel's spaceship as measured by Benji?

A. 0.4 c
B. 0.6 c
C. 0.8 c
D. c

Question 5

According to Einstein's theory of special relativity, which one of the following does not depend on the motion of the observer?

A. the order of occurrence of two events
B. the time interval between two events
C. the distance between two points
D. the speed of light

Question 6

Michelson and Morley performed an experiment to measure the speed of light with respect to the ether. They believed that Earth moved in its orbit with speed v relative to the ether. They believed there should be a difference in the **measured** speed of light depending on whether it was measured parallel or perpendicular to the direction of Earth's movement through the ether.

The Michelson–Morley experiment found the ratio of

$$\frac{\text{the speed of light measured parallel to the Earth's motion through the ether}}{\text{the speed of light measured perpendicular to the Earth's motion through the ether}}$$

to be

A. slightly less than one.

B. equal to one.

C. slightly greater than one.

D. significantly greater than one.

Question 7

In a nuclear reactor, some mass is converted into energy.

Which one of the following is the best approximation to the total energy released when 1 kg of mass is totally converted into energy?

A. 10^5 J

B. 10^9 J

C. 10^{13} J

D. 10^{17} J

Question 8

According to Einstein's special theory of relativity, the relativistic mass, m, of a body of rest mass m_0, depends on its speed.

Which one of the curves in Figure 2 best shows how the relativistic mass varies with speed?

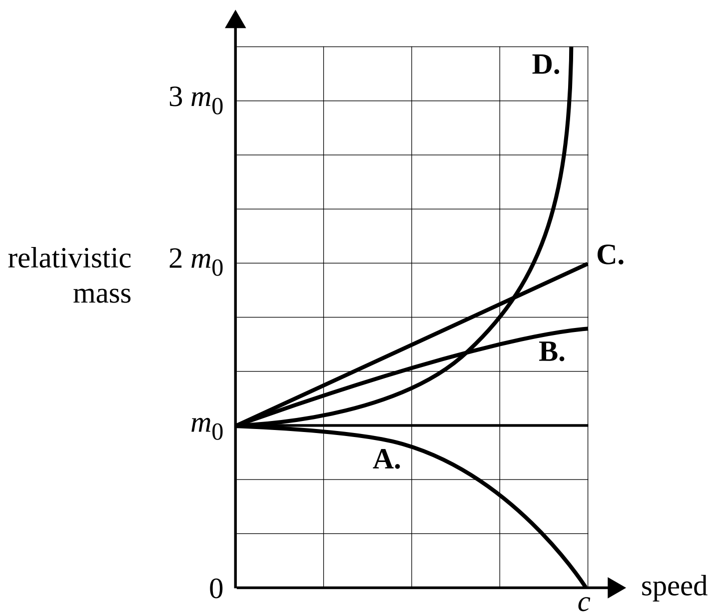


Figure 2

The following information relates to Questions 9 and 10.

An experiment is set up in an accelerator laboratory to study muons. A muon is an elementary particle. The muons are moving at a speed of 0.95 c ($\gamma = 3.2$). However, a particular muon only exists for a period of time of 4.8×10^{-6} s (as measured by the experimenters). After this time the muon decays into other particles.

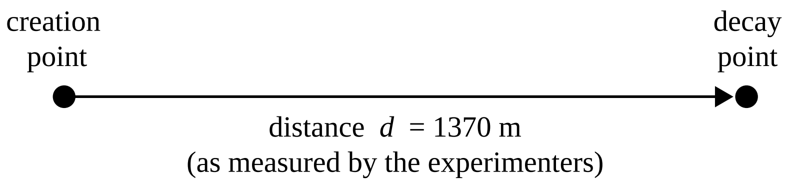


Figure 3

Question 9

Which one of the following best gives the lifetime of the muon as measured in its own frame of reference?

A. 4.7×10^{-7} s

B. 1.2×10^{-6} s

C. 1.5×10^{-6} s

D. 4.6×10^{-6} s

Question 10

Which one of the following best gives the distance between the creation point and the decay point as measured in the frame of reference of the muon?

A. 1370 m

B. 450 m

C. 428 m

D. 134 m

Question 11

Which one of the following is closest to the work that must be done on a proton to increase its speed from zero to 0.9 c, that is $\gamma = 2.29$? (Take m_0 for the proton = 1.67×10^{-27} kg.)

A. 1.9×10^{-10} J

B. 4.0×10^{-20} J

C. 3.5×10^{-11} J

D. 1.7×10^{-27} J

Question 12

In science fiction, spacecraft sometimes travel at speeds greater than the speed of light.

According to Einstein's special theory of relativity, this is not possible because

A. this would require time travel into the past.

B. when an object approaches the speed of light, the rest mass tends towards zero.

C. when an object approaches the speed of light, the value of γ tends towards zero.

D. when an object approaches the speed of light, its relativistic mass, m, approaches infinity.

Question 13

Which one of the following statements is the best statement about inertial frames of reference?

A. Inertial frames must be stationary.

B. Inertial frames must be accelerating.

C. The laws of physics have the same form in all inertial frames.

D. Inertial frames cannot be moving at close to the speed of light.

END OF DETAILED STUDY 1

Detailed study 2 – Materials and their use in structures

The following information relates to Questions 1–7.

The mechanical properties of steel depend on how it is produced.

Figure 1 shows the stress-strain graphs for **hard steel** and **soft steel** under tension.

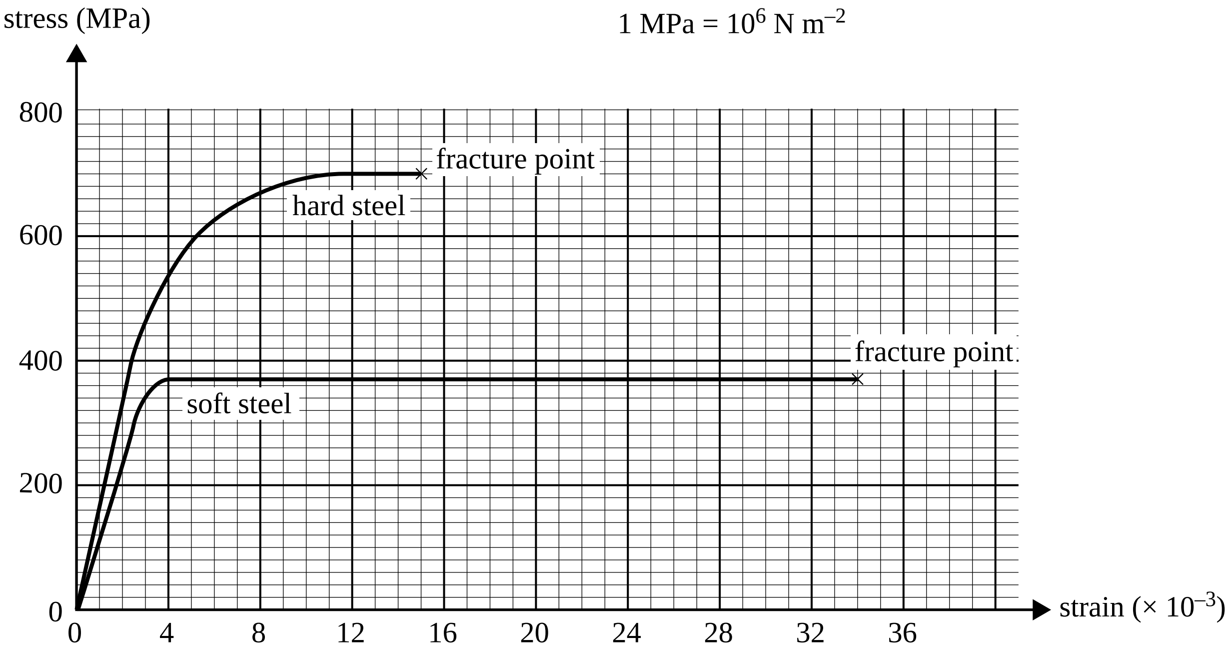


Figure 1

Question 1

From the graph, compared to hard steel, soft steel can best be described as

A. stiff.

B. strong.

C. brittle.

D. ductile.

Question 2

Which one of the following statements indicates that hard steel is stiffer than soft steel?

A. Hard steel undergoes less plastic deformation than soft steel.

B. A greater stress is needed to fracture hard steel than soft steel.

C. The area under the graph is greater for hard steel than soft steel.

D. The gradient of the stress-strain curve is greater for hard steel than soft steel.

Question 3

Which one of the following statements about toughness is correct?

A. Soft steel is tougher than hard steel.

B. Hard steel is tougher than soft steel.

C. Both hard steel and soft steel are equally tough.

D. To decide which steel is tougher, the volume of both must be known. There is insufficient information to decide.

Question 4

A rod of soft steel, of initial length 10.0000 m, is placed under a tensile stress.

The strain produced by this stress is 1.000×10^{-3}

Which one of the options below is the best estimate of the length of this rod under this stress?

A. 9.990 m

B. 9.999 m

C. 10.001 m

D. 10.010 m

Question 5

Which one of the options below is the best estimate of Young's modulus for **hard steel** under tension?

A. 1.2×10^{11} N m^{-2}

B. 1.6×10^{5} N m^{-2}

C. 1.6×10^{8} N m^{-2}

D. 1.6×10^{11} N m^{-2}

A cylindrical rod of length 2.0 m and cross-sectional area 8.0×10^{-5} m^{2} is made of **hard steel**. The rod is placed under a tensile stress of 200 MPa.

Question 6

Which one of the following is the best estimate of the force that must be applied to this hard steel rod to provide this stress?

A. 8.0×10^{3} N

B. 1.6×10^{4} N

C. 1.6×10^{10} N

D. 2.5×10^{12} N

Question 7

A stress of 200 MPa applied to this hard steel cylindrical rod produces a strain of 1.25×10^{-3}.

The strain energy (energy per unit volume) stored is closest to

A. 1.0×10^{1} J m^{-3}

B. 1.3×10^{5} J m^{-3}

C. 7.8×10^{8} J m^{-3}

D. 1.6×10^{9} J m^{-3}

The diagram below (Figure 2) shows a mass of 100 kg hanging from the end of a 1.20 m uniform beam **P S** of mass 20 kg. The beam is pivoted at the point P, with a freely rotating link.

The beam is supported by a cable of negligible mass, connected at the point R. The point R is 0.80 m from P. The cable makes an angle of 30° to the horizontal (60° to the wall).

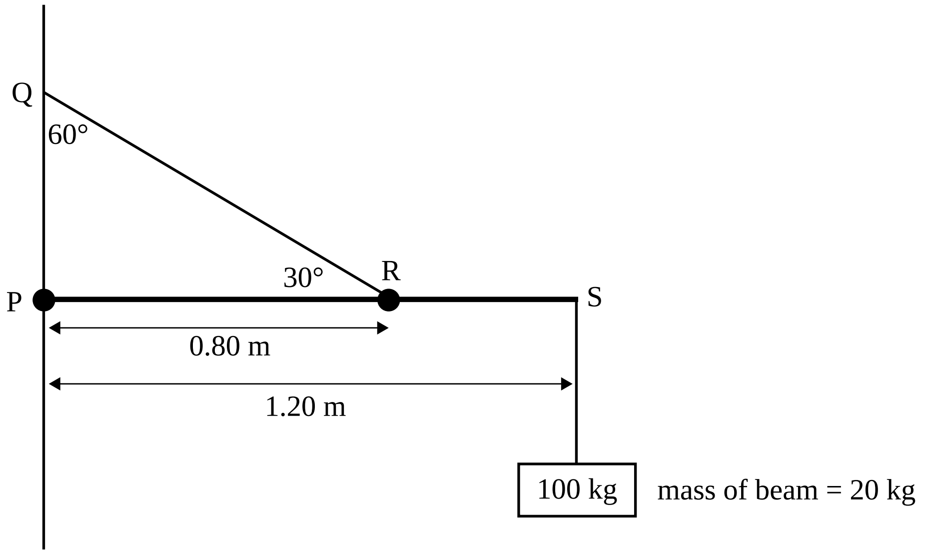


Figure 2

Question 8

Which one of the following options best gives the magnitude of the torque on the beam about the point P due to the weight of the 100 kg mass?

A. 60 N m

B. 120 N m

C. 600 N m

D. 1200 N m

Question 9

Which one of the following best gives the sum of all the torques acting on the beam about the point P?

A. 0 N m

B. 120 N m

C. 600 N m

D. 1200 N m

Question 10

Which one of the following best gives the tension in the cable RQ?

A. 120 N

B. 1320 N

C. 1905 N

D. 3300 N

Figure 3 shows a suspended concrete walkway. The walkway is supported by cables from above.

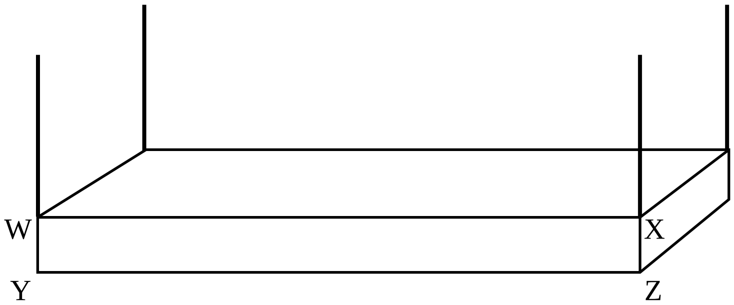
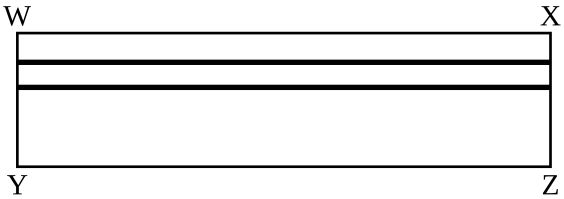


Figure 3

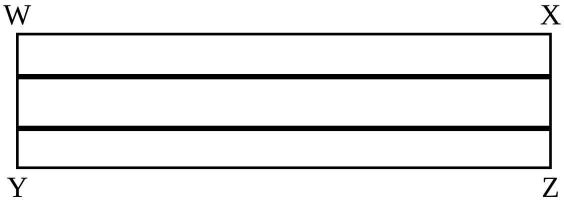
Question 11

Which sketch below shows the best placement of reinforcing steel rods (represented by the pairs of thick black lines) in order to provide maximum strength for concrete in the walkway?

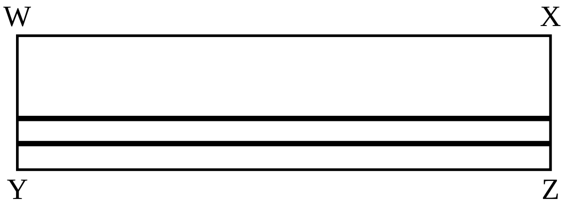
A.



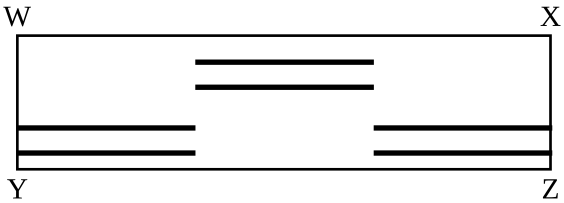
B.



C.



D.



A beam of length 12.0 m and mass 1200 kg is resting on two pillars, A and B. A mass of 600 kg is hung by a wire from the beam, a distance 3.0 m from pillar B.

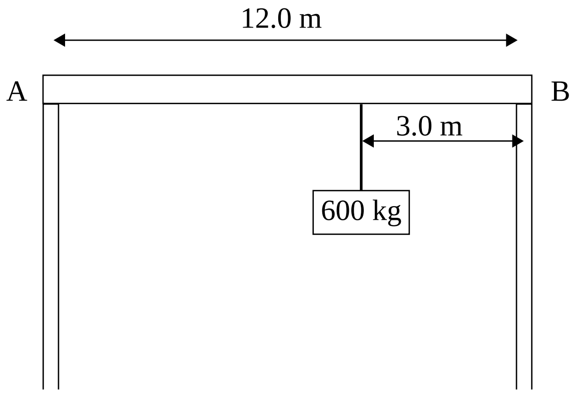


Figure 4

Question 12

Which one of the options below is the best estimate of the force exerted by the beam on pillar B?

A. 7 500 N

B. 9 000 N

C. 10 500 N

D. 18 000 N

Question 13

Figure 5 shows a stable stone arch. It is made of suitably shaped stone blocks.

There is no cement or other adhesive between the blocks to bind them together.

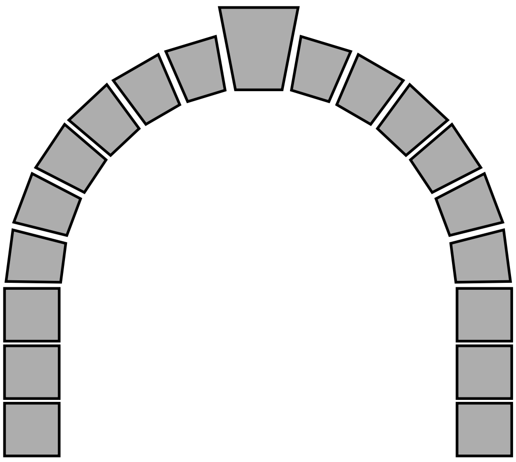


Figure 5

Stone is used in an arch because arches require a material that is

A. strong under shear stress.

B. strong under tensile stress.

C. strong under compressive stress.

D. ductile under compressive stress.

END OF DETAILED STUDY 2

Detailed study 3 – Further electronics

The following information relates to Questions 1–6.

Jenny is building an AC to DC regulated smoothed power supply. She sets up the first part of the circuit, as shown in Figure 1.

The input of the transformer is 240 V_{RMS} AC, 50 Hz, and the output 10.5 V_{RMS} AC.

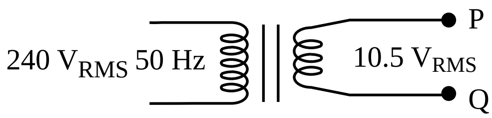


Figure 1

Question 1

Assuming an ideal transformer, which one of the following best gives the ratio of turns in the primary (N_1) to turns in the secondary (N_2)?

A. 210 : 4800

B. 300 : 4800

C. 4800 : 300

D. 4800 : 210

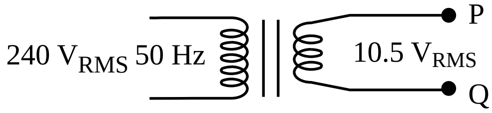


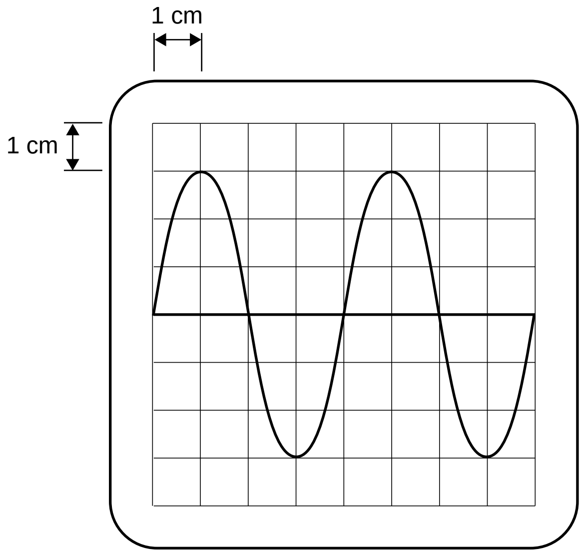
Figure 1 (repeated)

Jenny connects an oscilloscope across the output terminals, PQ, of the transformer (See Figure 1). The vertical scale of the oscilloscope is set on 5 V/cm, and the horizontal scale on 5 ms/cm.

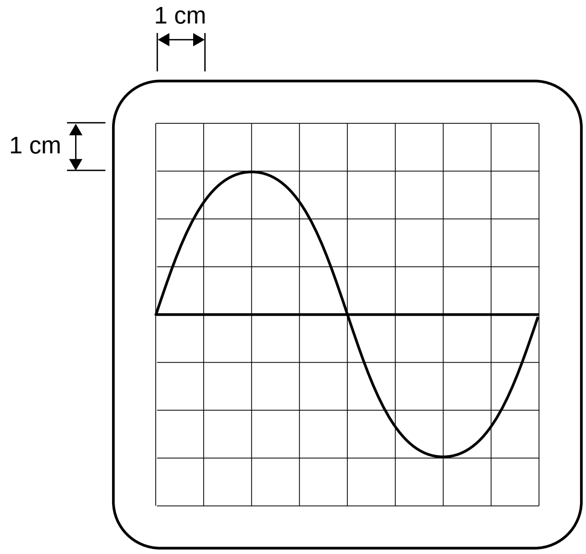
Question 2

Which one of the displays below will she observe?

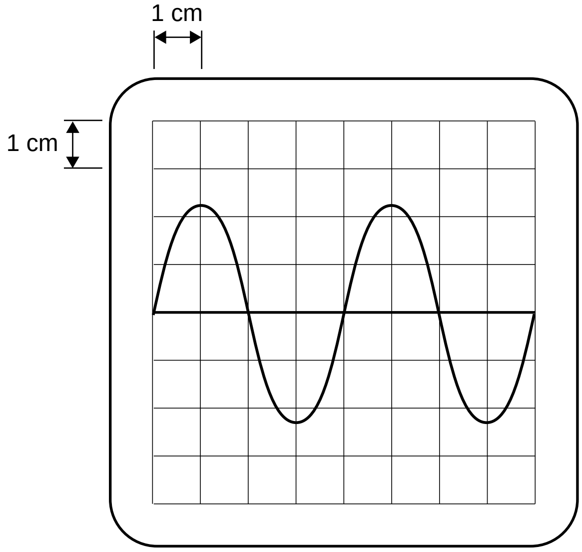
A.



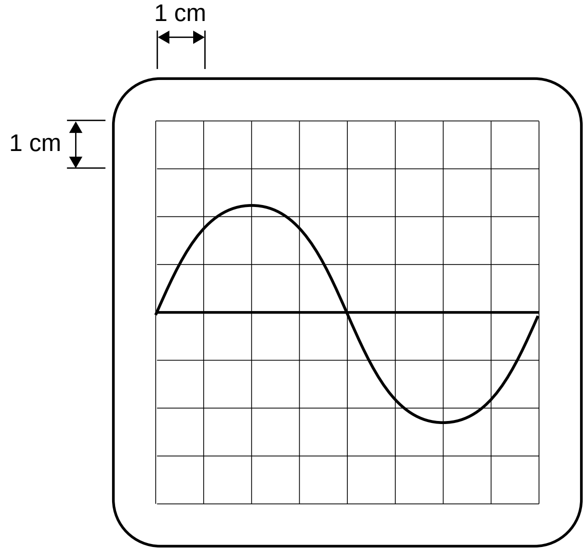
B.



C.



D.



Jenny next adds a full-wave diode bridge rectifier, a 10 μF capacitor and a 500 Ω load resistor, as shown in Figure 2.

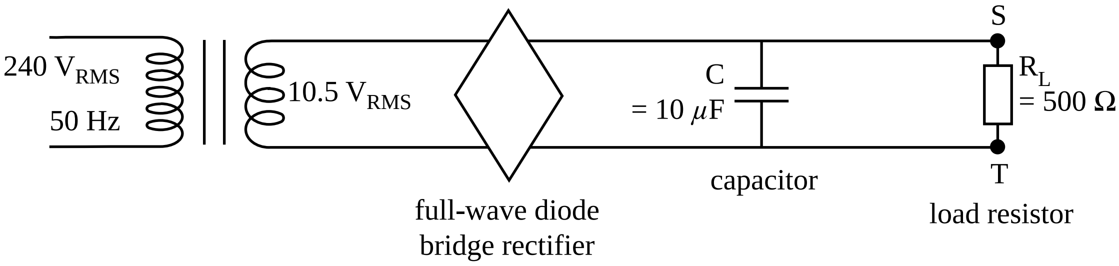


Figure 2

Jenny connects the oscilloscope across the load resistor (ST). The output as measured by the oscilloscope is shown in Figure 3.

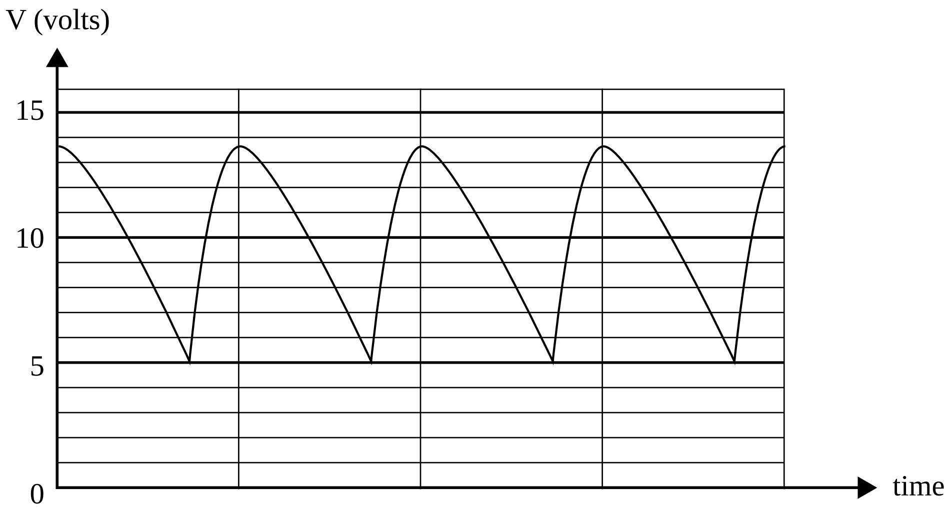


Figure 3

Question 3

Which one of the following is the best estimate of the average power dissipated in the 500 Ω load resistor?

A. 0.02 W

B. 0.2 W

C. 0.4 W

D. 5000 W

Question 4

Which one of the following is the best estimate of the peak-to-peak ripple voltage?

A. 0.5 V

B. 5.0 V

C. 8.5 V

D. 13.5 V

Jenny now adds a voltage regulator circuit consisting of a resistor, R_1, of 100 Ω and a 6 V Zener diode. The circuit is now set up as shown in Figure 4.

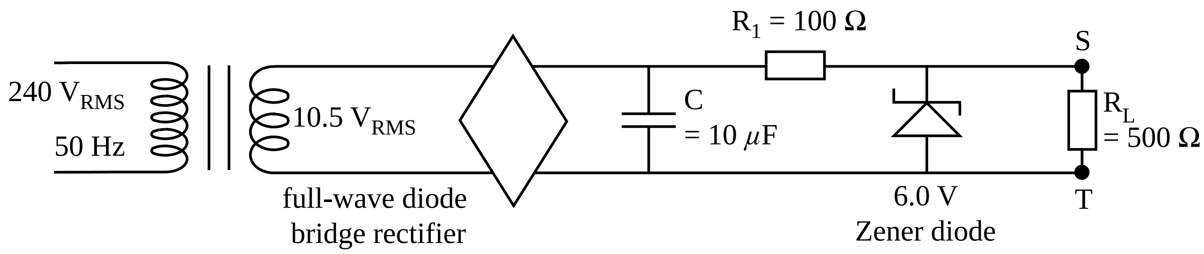


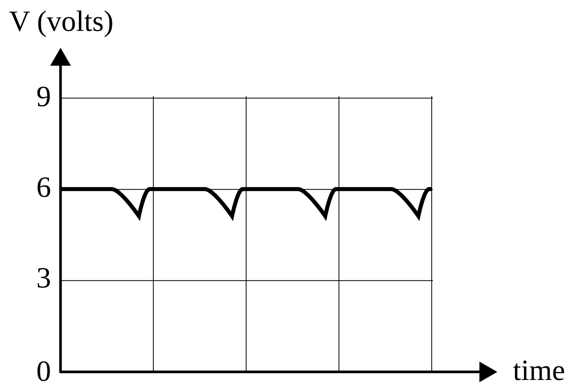
Figure 4

Jenny now connects the oscilloscope across the load resistor (ST).

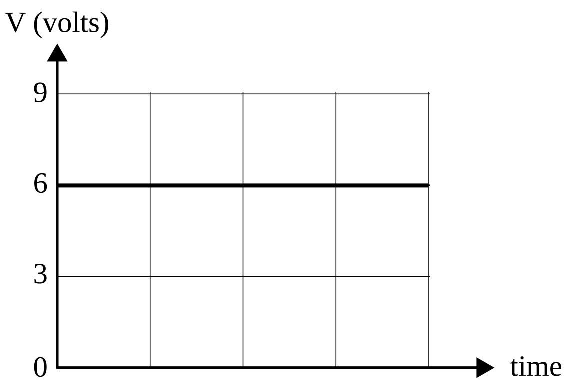
Question 5

Which one of the following best shows the output she will observe?

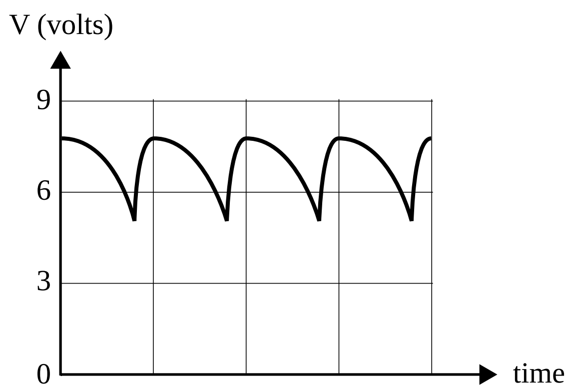
A.



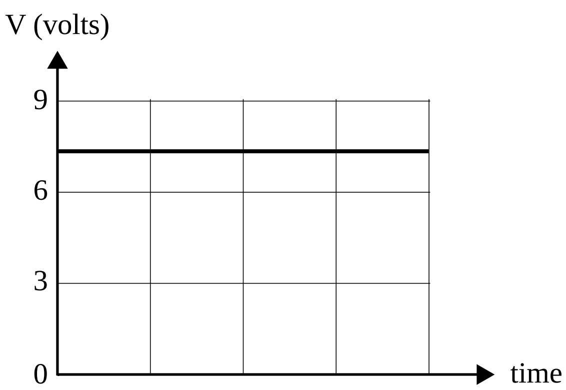
B.



C.



D.



Jenny finds that the ripple voltage is too great for the application for which she wants to use her power supply.

Question 6

Which one of the following changes would best reduce the ripple voltage?

A. replace R_1 with a 50 Ω resistor

B. replace the 6 V Zener diode with a 9 V one

C. replace the capacitor with a 500 μF capacitor

D. replace the transformer with one with a 9.0 V_{RMS} output

The following information relates to Questions 7–9.

An RC circuit is shown below in Figure 5.

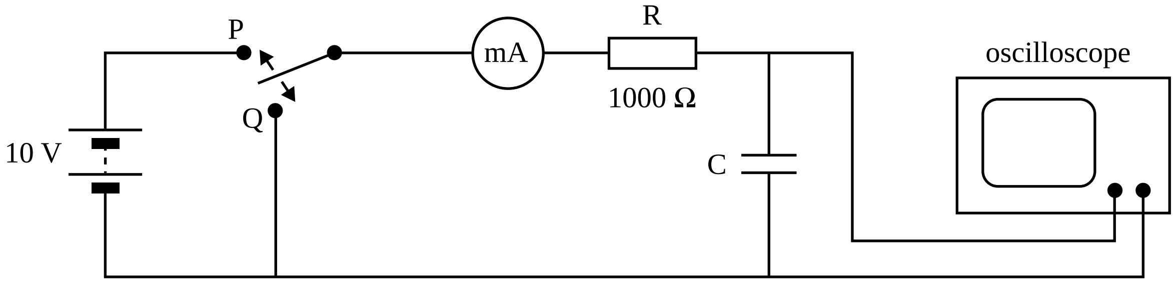


Figure 5

With the capacitor discharged, the switch is moved to position P at time $t = 0$.

The voltage across the capacitor, C, as measured by the oscilloscope is shown in Figure 6.

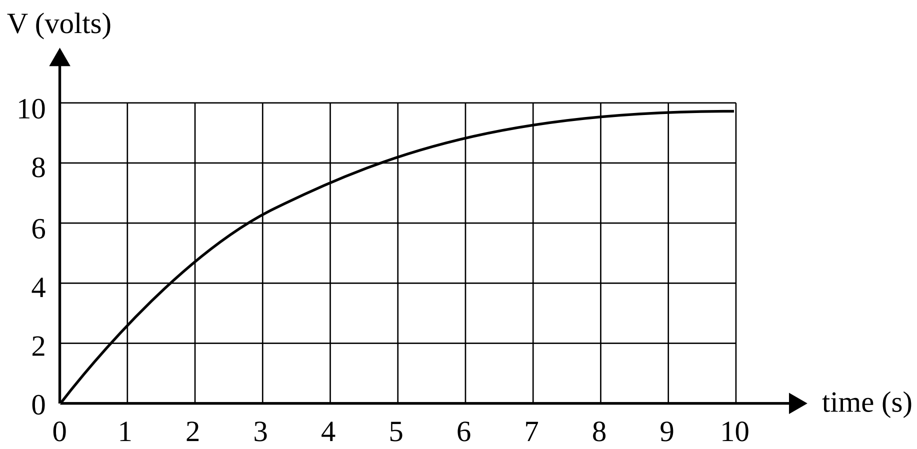


Figure 6

Question 7

Which one of the following is the best estimate of the value of the capacitor C?

A. 3 μF

B. 1 000 μF

C. 3 000 μF

D. 10 000 μF

Question 8

After 60 s the switch is moved to position Q.

Which one of the following best gives the **initial** current flowing through the milliammeter?

A. 0 mA

B. 6.3 mA

C. 10 mA

D. 10 A

Question 9

Which one of the following best gives the voltage measured across the capacitor, C, 3 s after the switch is moved to Q?

A. 0 V

B. 3.7 V

C. 6.3 V

D. 10.0 V

A circuit contains an AC power source, four diodes and a load resistor as shown in Figure 7.

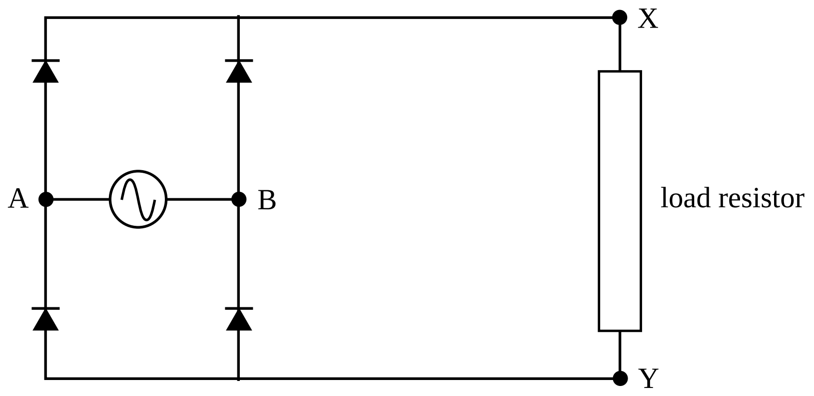


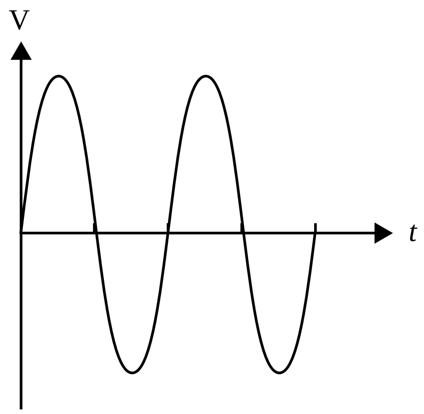
Figure 7

Sally connects an oscilloscope across the load resistor, that is, across XY.

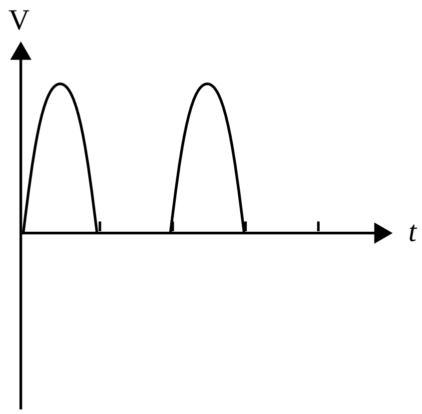
Question 10

Which one of the following outputs will she most likely observe?

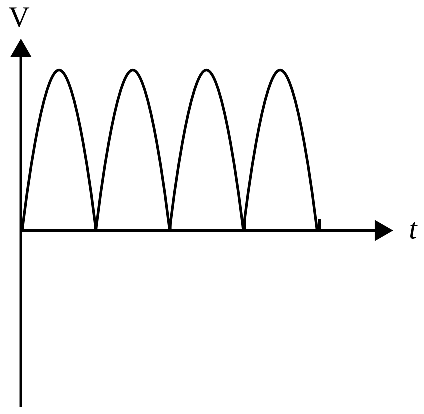
A.



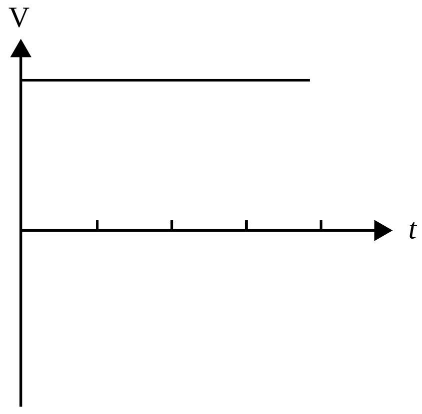
B.



C.



D.



Question 11

Michael has a transformer connected to an oscilloscope. The circuit and the output of the transformer are shown in Figure 8.

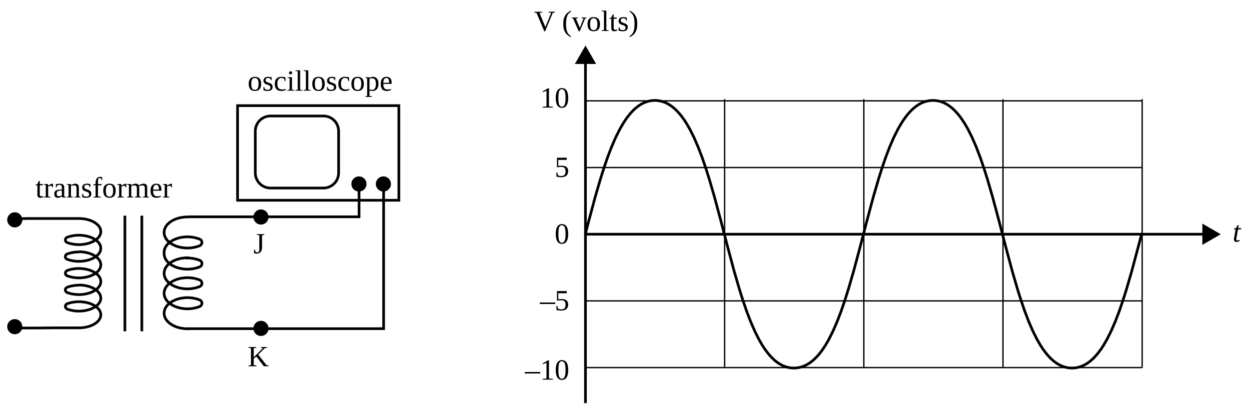


Figure 8

Michael now connects a multimeter set on AC volts across the terminals, JK, of the transformer.

Which one of the following best gives the reading he will observe on the multimeter?

A. 7 V

B. 10 V

C. 14 V

D. 20 V

The following information relates to Questions 12 and 13.

John is studying the operation of a Zener diode. The voltage-current characteristics of the Zener diode are shown in Figure 9.

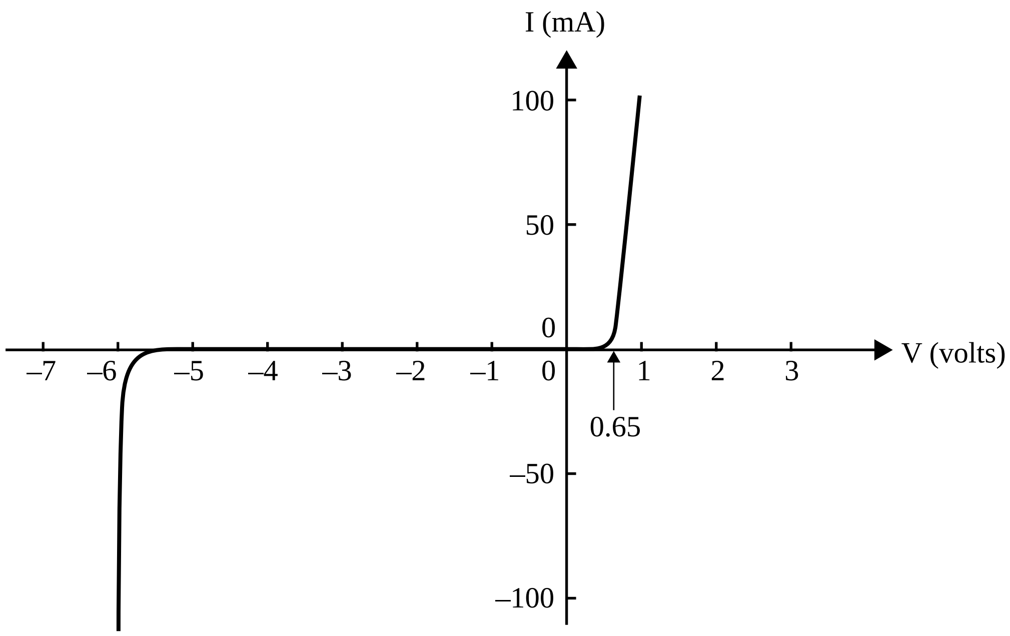


Figure 9

John sets up the following circuit shown in Figure 10.

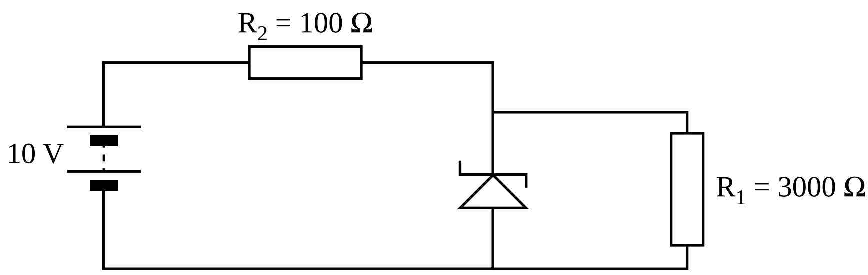


Figure 10

Question 12

Which one of the following best gives the voltage he will observe across R_2?

A. 0 V

B. 4 V

C. 6 V

D. 10 V

Question 13

Which one of the following best gives the current through the Zener diode?

A. 1 mA

B. 2 mA

C. 38 mA

D. 40 mA

END OF QUESTION AND ANSWER BOOK

PHYSICS

Written examination 1

FORMULA SHEET

Directions to students

Detach this formula sheet before commencing the examination.

This formula sheet is provided for your reference.

1	velocity; acceleration	$v = \frac{\Delta x}{\Delta t}$; $a = \frac{\Delta v}{\Delta t}$
2	equations for constant acceleration	$v = u + at$ $x = ut + \frac{1}{2}at^2$ $v^2 = u^2 + 2ax$ $x = \frac{1}{2}(v + u)t$
3	Newton's second law	$F = ma$
4	circular motion	$a = \frac{v^2}{r} = \frac{4\pi^2 r}{T^2}$
5	Hooke's law	$F = -kx$
6	elastic potential energy	$\frac{1}{2}kx^2$
7	gravitional potential energy near the surface of the Earth	mgh
8	kinetic energy	$\frac{1}{2}mv^2$
9	Newton's law of universal gravitation	$F = G\frac{M_1 M_2}{r^2}$
10	gravitational field	$g = G\frac{M}{r^2}$
11	stress	$\sigma = \frac{F}{A}$
12	strain	$\varepsilon = \frac{\Delta L}{L}$
13	Young's modulus	$E = \frac{\text{stress}}{\text{strain}}$
14	transformer action	$\frac{V_1}{V_2} = \frac{N_1}{N_2}$
15	AC voltage and current	$V_{\text{RMS}} = \frac{1}{2\sqrt{2}}V_{\text{p-p}}$ $I_{\text{RMS}} = \frac{1}{2\sqrt{2}}I_{\text{p-p}}$
16	voltage; power	$V = RI$ $P = VI = I^2R$

17	resistors in series	$R_T = R_1 + R_2$
18	resistors in parallel	$\frac{1}{R_T} = \frac{1}{R_1} + \frac{1}{R_2}$
19	capacitors	time constant : $\tau = RC$
20	Lorentz factor	$\gamma = \frac{1}{\sqrt{1 - v^2 / c^2}}$
21	time dilation	$t = t_o \gamma$
22	length contraction	$L = L_o / \gamma$
23	relativistic mass	$m = m_o \gamma$
24	Total energy	$E_{total} = E_k + E_{rest} = mc^2$
25	universal gravitational constant	$G = 6.67 \times 10^{-11}$ N m^2 kg^{-2}
26	mass of Earth	$M_E = 5.98 \times 10^{24}$ kg
27	radius of Earth	$R_E = 6.37 \times 10^6$ m
28	mass of the electron	$m_e = 9.1 \times 10^{-31}$ kg
29	charge on the electron	$e = -1.6 \times 10^{-19}$ C
30	speed of light	$c = 3.0 \times 10^8$ m s^{-1}

Prefixes/Units

p = pico = 10^{-12}

n = nano = 10^{-9}

μ = micro = 10^{-6}

m = milli = 10^{-3}

k = kilo = 10^3

M = mega = 10^6

G = giga = 10^9

t = tonne = 10^3 kg

END OF FORMULA SHEET