VICTORIAN CURRICULUM AND ASSESSMENT AUTHORITY

Victorian Certificate of Education 2004

SUPERVISOR TO ATTACH PROCESSING LABEL HERE

STUDENT NUMBER

									Letter
Figures									
Words									

PHYSICS – PILOT STUDY

Written examination 1

Monday 7 June 2004

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 or two dimensions	15	15	40
2. Electronics and photonics	12	12	25
B – Detailed studies			
1. Einstein's relativity (page 18)	11	11	25
OR			
2. Investigating structures and materials (page 24)	11	11	25
OR			
3. Further electronics (page 31)	12	12	25
			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 an approved graphics calculator (memory cleared) and/or 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 36 pages, with a detachable data sheet in the centrefold.

Instructions
- Detach the data sheet from the centre of this book during reading time.
- Write your **student number** in the space provided above on this page.
- Answer all questions in the spaces provided.
- **Always** show your working where space is provided
- Where an answer box has a unit printed in it, give your answer in that unit.
- All written responses must be in English.

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

SECTION A – Core

Instructions for Section A

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

Area of study 1 – Motion in one and two dimensions

In the following questions you should take the value of g to be 10 m s^{-2}

A bushwalker is stranded while walking. Search and rescue officers drop an emergency package from a helicopter to the bushwalker. They release the package when the helicopter is a height (h) above the ground, and directly above the bushwalker. The helicopter is moving with a velocity of 10 m s^{-1} at an angle of 30° to the horizontal, as shown in Figure 1. The package lands on the ground 3.0 s after its release. Ignore air resistance in your calculations.

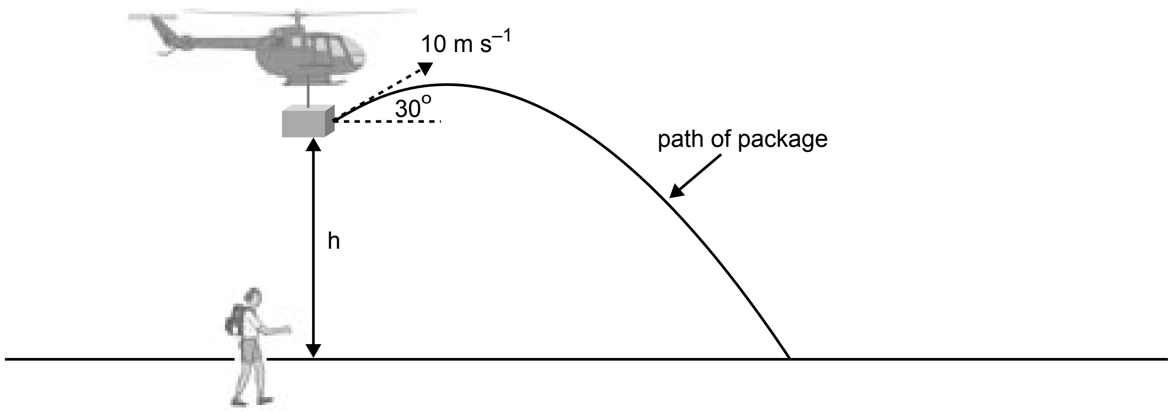


Figure 1

Question 1

What is the value of h in Figure 1?

m

3 marks

Question 2

Assuming that the helicopter continues to fly with its initial velocity, where is it when the package lands? Which one of the statements below is most correct?

A. It is directly above the package.

B. It is directly above a point that is 15 m beyond the package.

C. It is directly above a point that is 26 m beyond the package.

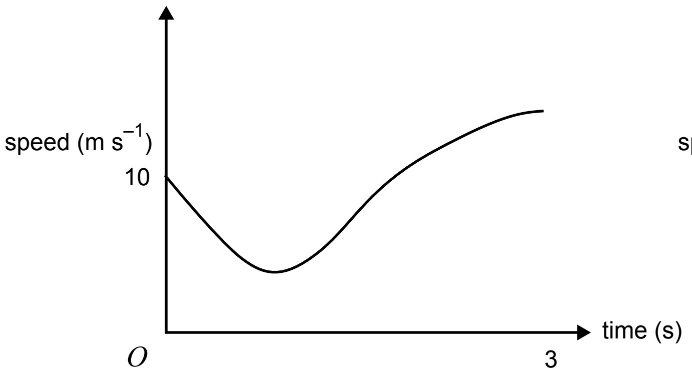
D. It is directly above a point that is 30 m from the bushwalker.

2 marks

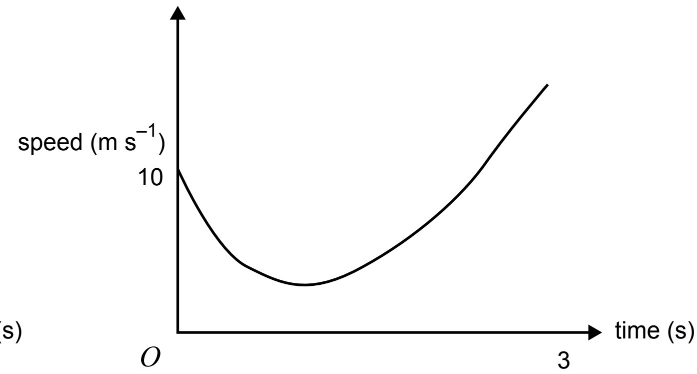
Question 3

Which of the graphs below best represents the **speed** of the package as a function of time?

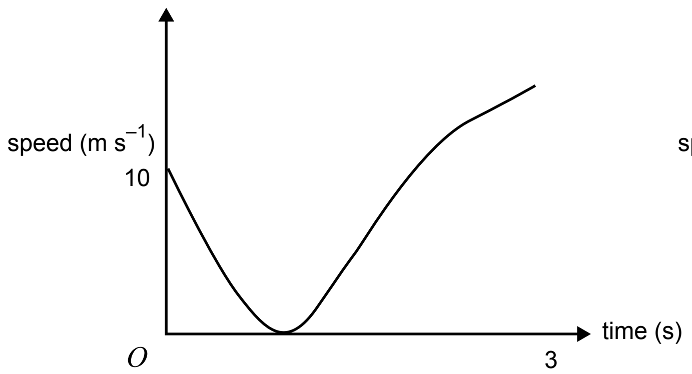
A.



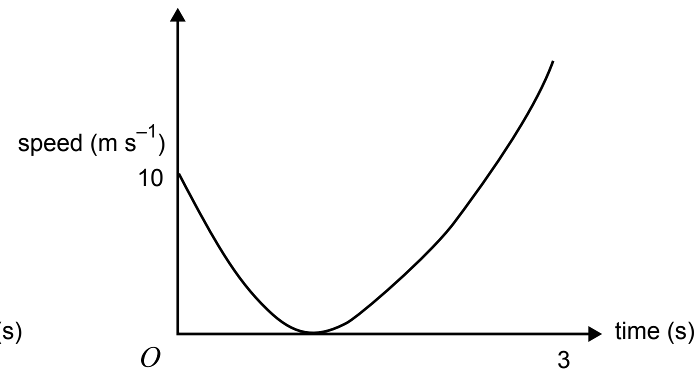
B.



C.



D.



2 marks

A car of mass 1000 kg travelling on a smooth road at 5.0 m s^{-1} collides with a truck that is stationary at a set of traffic lights. After the collision they are stuck together and move off with a speed of 2.0 m s^{-1}.

Question 4

How much momentum did the car transfer to the truck?

kg m s^{-1}

3 marks

Question 5

What is the mass of the truck?

kg

3 marks

Question 6

If the collision took place over a period of 0.3 s, what was the average force exerted by the car on the truck?

N

4 marks

A train is travelling at a constant velocity on a level track. Lee is standing in the train, **facing the front**, and throws a ball vertically up in the air, and observes its motion.

Question 7

In the space below, describe the motion of the ball as seen by Lee.

2 marks

Sam, who is standing at a level crossing, sees Lee throw the ball into the air.

Question 8

In the space below, **describe and explain** the motion of the ball as seen by Sam.

3 marks

In Figure 2, a car of mass 1000 kg is being towed on a level road by a van of mass 2000 kg. There is a **constant retarding force**, due to air resistance and friction, of 500 N on the van, and 300 N on the car. The vehicles are travelling at **a constant speed**.

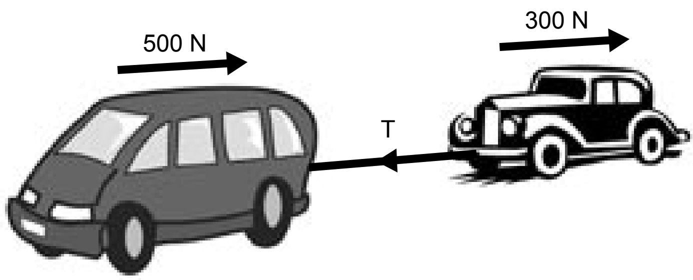


Figure 2

Question 9

What is the magnitude of the force driving the van?

N

2 marks

Question 10

What is the value of the tension, T, in the towbar?

N

2 marks

When travelling at a speed of 15.0 m s^{-1} the van driver stops the engine, and the van and car slow down at a constant rate due to the constant retarding forces acting on the vehicles.

Question 11

How far will the van and car travel before coming to rest?

m

3 marks

CONTINUED OVER PAGE

The radius of the orbit of Earth in its circular motion around the Sun is 1.5×10^{11} m (Figure 3).

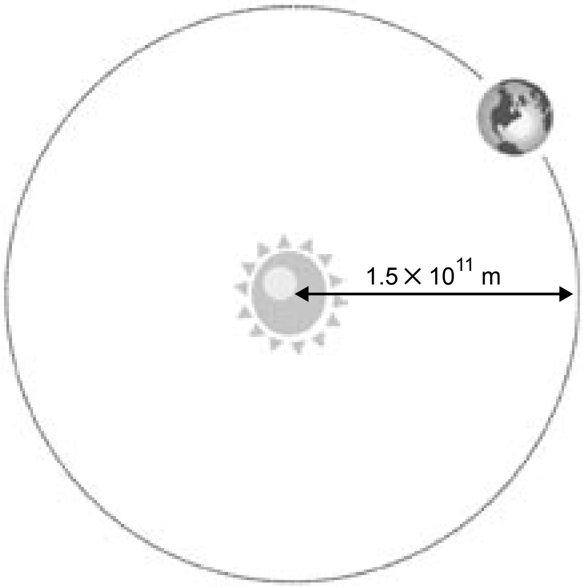


Figure 3

Question 12

Indicate on the diagram, with an arrow, the direction of the acceleration of Earth.

1 mark

Question 13

Calculate the mass of the Sun. Take the value of the gravitational constant $G = 6.67 \times 10^{-11}$ N m^2 kg^{-2}.

kg

3 marks

In a storeroom a small box of mass 30.0 kg is loaded onto a slide from the second floor, and slides from rest to the ground floor below, as shown in Figure 4. The slide has a **linear length of 6.0 m**, and is designed to **provide a constant friction force** of 50 N on the box. The box reaches the end of the slide with a speed of 8.0 m s^{-1}.

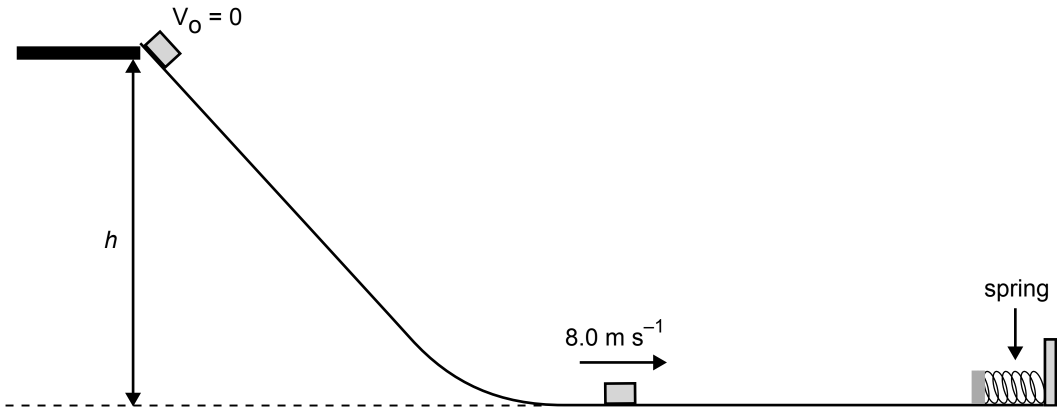


Figure 4

Question 14
What is the height, h, between the floors?

m

4 marks

The box then slides along the **frictionless floor**, and is momentarily stopped by a spring of stiffness 30 000 N m^{-1}.

Question 15
How far has the spring compressed when the box has come to rest?

m

3 marks

Area of study 2 – Electronics and photonics

An essential component in some of the practical circuits covered in this exam paper is the voltage divider. A DC voltage divider circuit is shown in Figure 1.

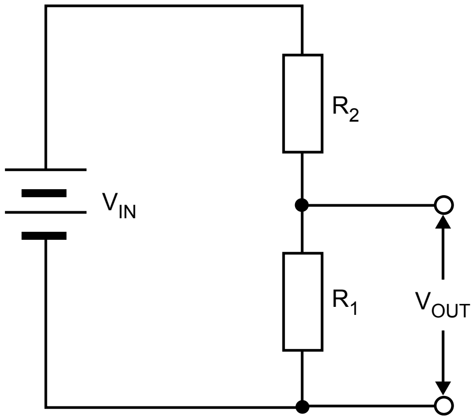


Figure 1

For the circuit of Figure 1, V_{IN} = 30 V, R_1 = 5 kΩ and the output voltage V_{OUT} = 6 V.

Question 1

What is the value of the resistance R_2? Show your working.

kΩ

2 marks

Question 2

You wire up the circuit shown in Figure 1 but only have 10 kΩ resistors to work with. Explain how you would construct the R_1 = 5 kΩ resistor using only 10 kΩ resistors. Include a sketch to show the connections between the appropriate number of 10 kΩ resistors.

2 marks

In Figure 1 the 30 V DC input to the voltage divider is replaced by a 100 mV (peak-to-peak) sinusoidal AC input voltage. The resistance values are now R_1 = 5 kΩ and R_2 = 15 kΩ.

Question 3

What is the current through resistor R_2? Show your working, and express your answer as a peak-to-peak current in μA.

μA

2 marks

Figure 1 is modified so that R_1 has a capacitor, C, placed in parallel with it. The new circuit is shown in Figure 2, and can now have an AC or DC input voltage, V_{IN}.

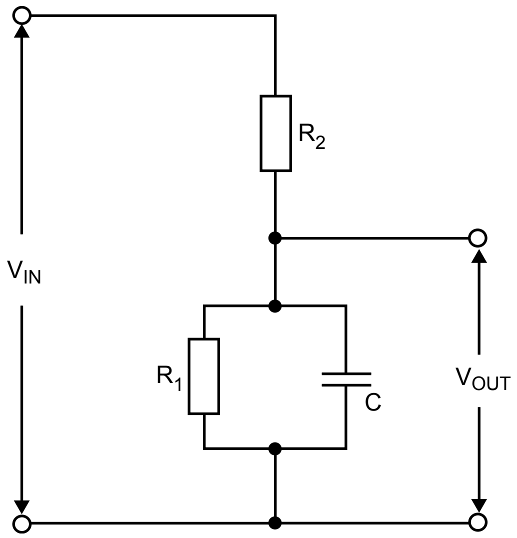


Figure 2

Question 4

It is observed that if V_{IN} is a DC voltage, then in the R_1–C parallel combination, a DC current passes through R_1, but not through C. However, if V_{IN} is a high frequency AC voltage, then an AC current passes mainly through C with very little through R_1. Explain this observation.

3 marks

These ideas are incorporated into the design of an n-p-n transistor amplifier circuit, shown in Figure 3, to amplify the small, high frequency AC voltage from a microphone. You may assume that the transistor is correctly biased.

The collector and base currents in Figure 3 are denoted respectively using lower case i_C and i_B to emphasise their AC time variation and small magnitude.

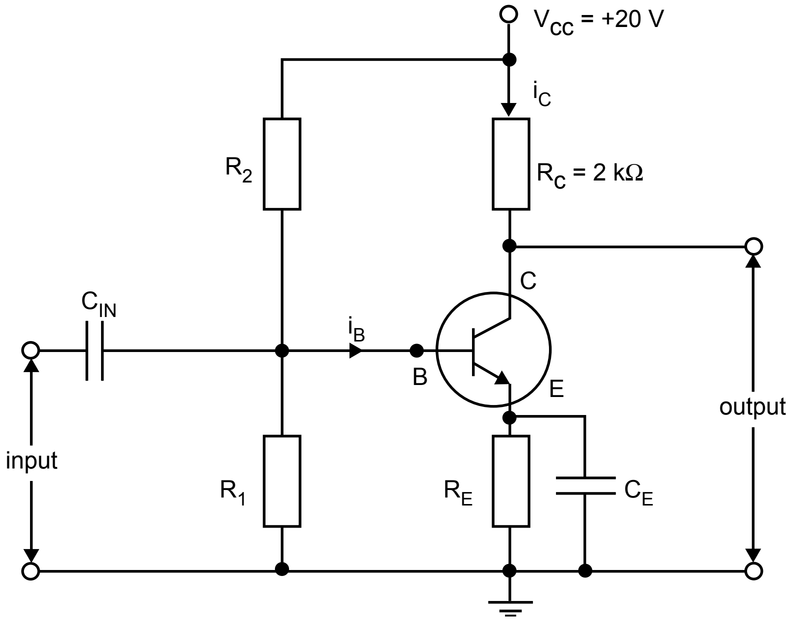


Figure 3

In this circuit the AC collector current, i_C, and the AC base current, i_B, are related by $i_C = 100\ i_B$.

The 10 mV (peak-to-peak) input voltage from the microphone gives rise to a time-varying base current of $i_B = 10\ \mu A$ (peak-to-peak).

Question 5

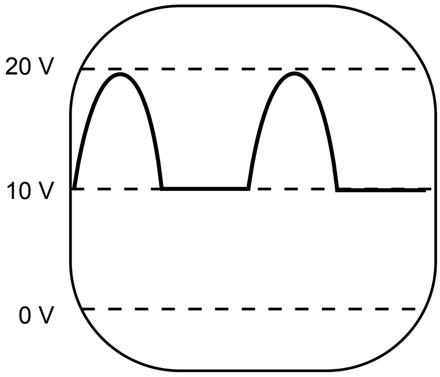
Calculate the AC voltage across the collector resistor, R_C, and show that the magnitude of the voltage gain of this transistor amplifier circuit is 200.

2 marks

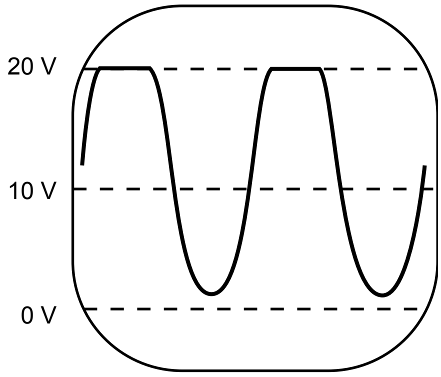
Question 6

Which one of the following cathode ray oscilloscope (CRO) traces of the output voltage (**A.–D.**) correctly identifies the distortion arising from transistor cut-off for the circuit of Figure 3? The input to this transistor amplifier circuit is a sinusoidal voltage.

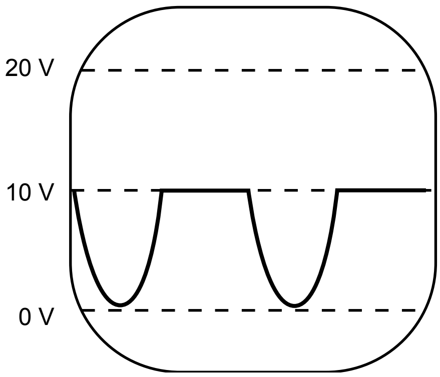
A.



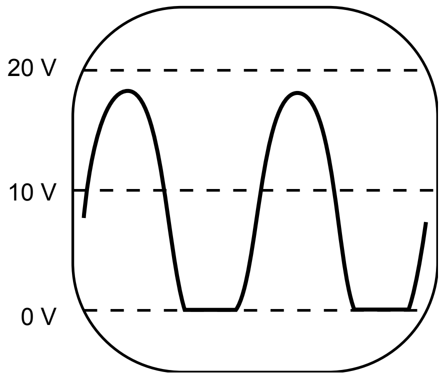
B.



C.



D.



2 marks

You are asked to investigate the properties of an optical coupler, sometimes called an opto-isolator. This comprises a light-emitting diode (LED) that converts an electrical signal into light output, and a phototransistor (PT) that converts incident light into an electrical output. Before using an opto-isolator chip you consider typical LED and PT circuits separately.

A simple LED circuit is shown in Figure 4 along with the LED current-voltage characteristics. The light output increases as the forward current, I_F, through the LED increases.

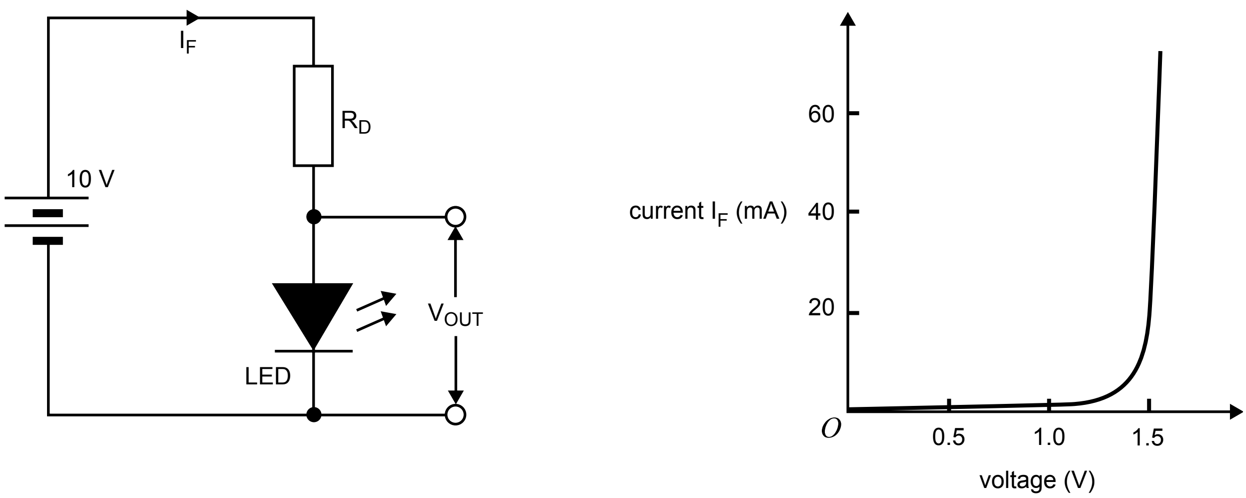


Figure 4

Question 7

Using the information in Figure 4, what is the value of the resistance, R_D, in series with the LED that will ensure the forward current through the LED is I_F = 10 mA?

Ω

2 marks

Question 8

Will the light output of the LED **increase** or **decrease** if the value of R_D is a little lower than the value you have calculated in Question 7? Justify your answer.

2 marks

Question 9

The LED in Figure 4 is an electro-optical converter.

Which one of the following statements (**A.–D.**) regarding energy conversion for the LED is correct?

All the electrical energy supplied from the DC power supply is converted

A. only to heat energy in both the resistor, R_D, and the LED.

B. partly to heat energy in the resistor, R_D, the remainder to light-energy output from the LED.

C. partly to heat energy in both the resistor, R_D, and the LED, with the remainder to light-energy output from the LED.

D. to heat energy in the LED, with the remainder to light-energy output from the LED.

2 marks

You now consider the phototransistor (PT) circuit of Figure 5 with R_C = 2.2 kΩ. The light is incident upon the base region of the PT and produces a collector current, I_C.

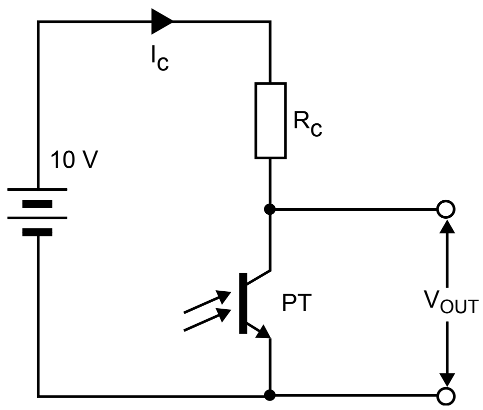


Figure 5

Question 10

As the light intensity incident on the PT increases, which one of the following statements concerning the PT-circuit of Figure 5 is correct?

A. The collector current remains constant, but V_{OUT} increases.

B. The collector current remains constant, but V_{OUT} decreases.

C. The collector current increases, but V_{OUT} decreases.

D. The collector current decreases and V_{OUT} decreases.

2 marks

Rather than use a separate LED and PT, you choose an opto-isolator chip (the region within the dotted lines) shown in the circuit of Figure 6. The opto-isolator is a linear device, that means that the PT collector current, I_C, and the LED forward current, I_F, are related by $I_C = \text{const} \times I_F$.

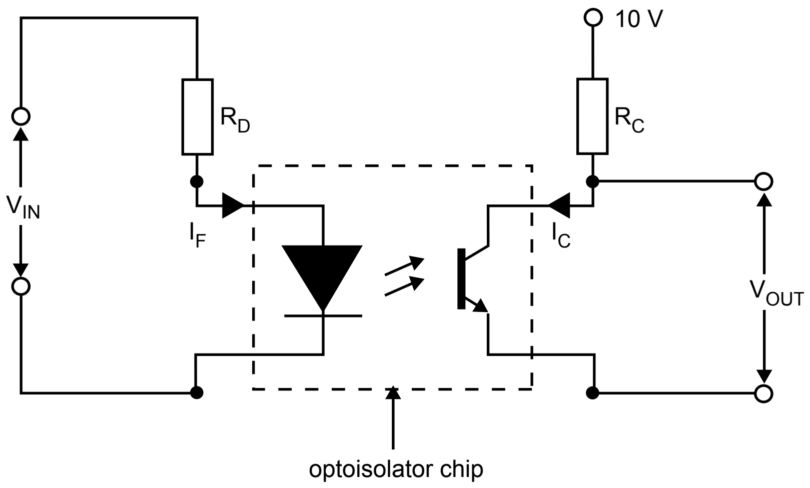


Figure 6

In addition you are also told that the opto-isolator has a switching time of 8 μs. This represents the time it takes for the PT collector current, I_C, to respond to a sudden change in light output from the LED.

Question 11

Figure 7a shows the LED forward current, I_F, as a function of time. On Figure 7b sketch the opto-isolator output collector current, I_C, as a function of time, given the initial condition (at t = 0) I_C = 4 mA when I_F = 20 mA.

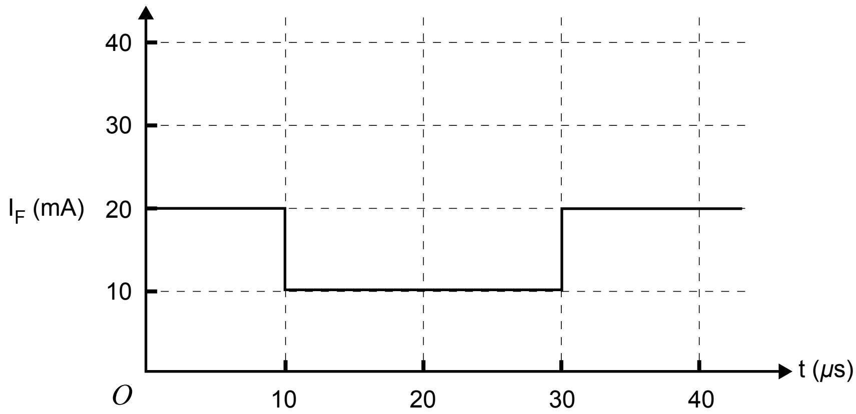


Figure 7a

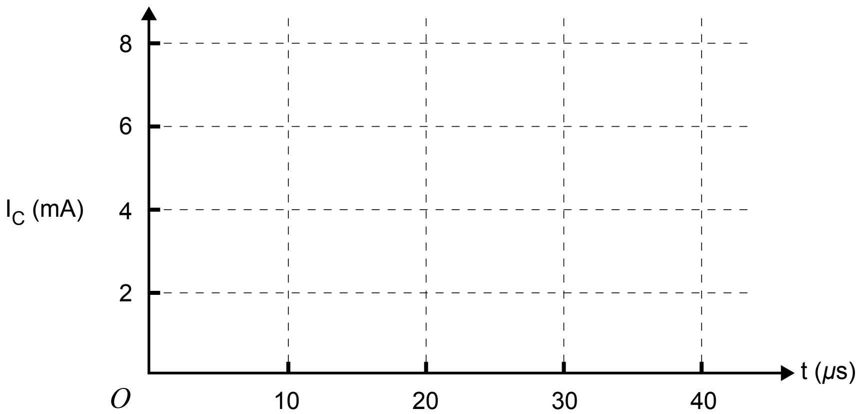


Figure 7b

2 marks

Question 12

Explain what you understand by the term bandwidth of a device. In your answer ensure that you state the name of the variable and the units that are normally used to specify bandwidth.

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 relativity

Val, Pat and Bruce are discussing the meaning of Einstein's famous equation $\boldsymbol{E = mc^2}$, when applied to an electron with mass $\boldsymbol{m}$.

> **Val** says that an electron will transform its mass m into an amount of pure energy E, when it is travelling at the speed of light (c).
>
> **Pat** disagrees, and says that if it were moving at a high velocity inside a cathode ray tube it would convert its mass m into a light photon of energy E when it hits the glass face.
>
> **Bruce**, on the other hand, thinks that just by its existence, the electron of mass m has an energy of E.

Question 1

In the box below write the name of the student with the best explanation of the equation.

2 marks

In 1861 James Clerk Maxwell proved that light was an electromagnetic wave with a speed of 3×10^8 m s^{-1}. Following Maxwell's predictions, physicists had some concerns.

Question 2

Which **one or more** of the statements (**A.–D.**) below outlines one of these concerns?

A. All waves propogate in a medium, but there was no medium in empty space.

B. Unlike the speed of other waves, experiments showed that the speed of light did not depend on the observer or source speed.

C. If light was a wave, it would not diffract.

D. The speed of light predicted by Maxwell did not agree with the measured speed.

2 marks

Imagine two students travelling in a spaceship toward the Sun at speed *v* (Figure 1). They plan to measure the speed of light in two experiments, as a test of the prediction of James Clerk Maxwell and that of Galilean relativity.

In the first experiment, they determine the speed of light (*c*) within the rocket ship by measuring the time for a short pulse of light emitted from a flashbulb at point A to reach point B. They got the accepted value for *c*. In the second experiment they determined the speed of light for a beam of light from the Sun, which passed through a porthole in the rocket nose. This was done by measuring the time for the light to travel between point A and point B.

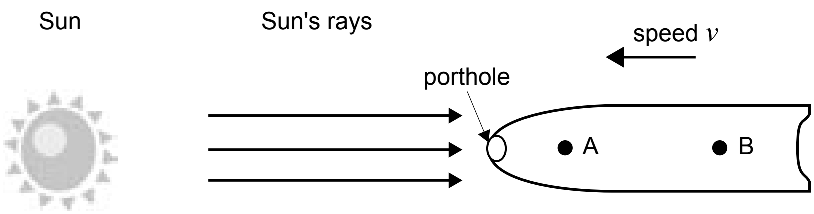


Figure 1

Question 3

Which one of the following statements (**A.–D.**) is consistent with the predictions of Maxwell, and of Galilean relativity, concerning the value of the speed of light obtained in this second measurement?

A. Both predict the speed to be *c*.

B. Maxwell's theory predicts the speed to be *c*, while Galilean relativity predicts a value of ($c + v$).

C. Maxwell's theory predicts a speed of ($c + v$), while Galilean relativity predicts a value of *c*.

D. Both predict the speed to be ($c + v$).

2 marks

In an experiment done at Massachusetts Institute of Technology, electrons were given a series of known kinetic energies (KE) by accelerating them across a range of electric potentials, and measuring the electron's velocity, v, for each value of KE.

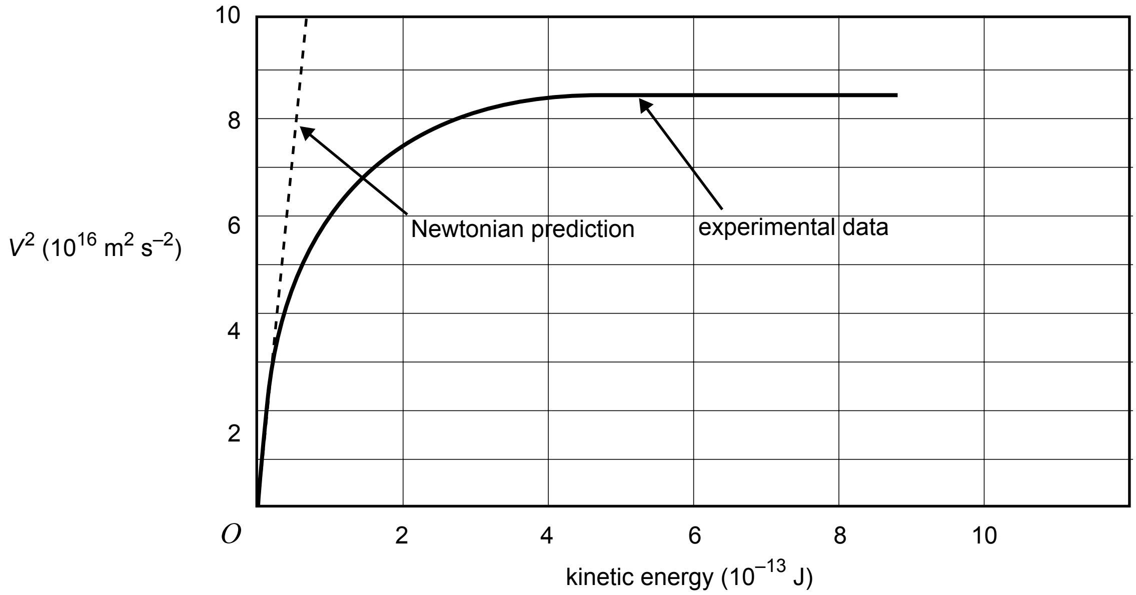


Figure 2

The solid curve in Figure 2 shows the variation of v^2 as a function of KE, as measured in the experiment. The dashed curve is the value of v^2 calculated using the Newtonian expression for kinetic energy.

Question 4

According to Newtonian mechanics, what would be the **speed** of an electron with a KE of 10×10^{-13} J?

The mass of an electron is 9.1×10^{-31} kg.

m s^{-1}

2 marks

Question 5

Using the experimental data shown in Figure 2, indicate in the box provided which one of the statements below gives the best estimate of the **measured speed** of an electron with a KE of 10×10^{-13} J.

A. It is approximately 9×10^{16} m s^{-1}.

B. It is approximately 3×10^{8} m s^{-1}.

C. It is approximately 9.1×10^{-31} m s^{-1}.

D. It cannot be estimated.

2 marks

In order to explain the propagation of a light wave, it was assumed in the late 19th century that all of space was filled with 'ether', which not only provided a medium for the wave, but also an absolute spatial reference frame. In order to check this, Michelson and Morley performed their famous experiment. A simplified plan of their equipment is shown below in Figure 3. The arrows show the direction in which the light is travelling. The intensity at the detector relied on interference between the light travelling the different paths. The apparatus was mounted on a rigid stand so that it could be rotated.

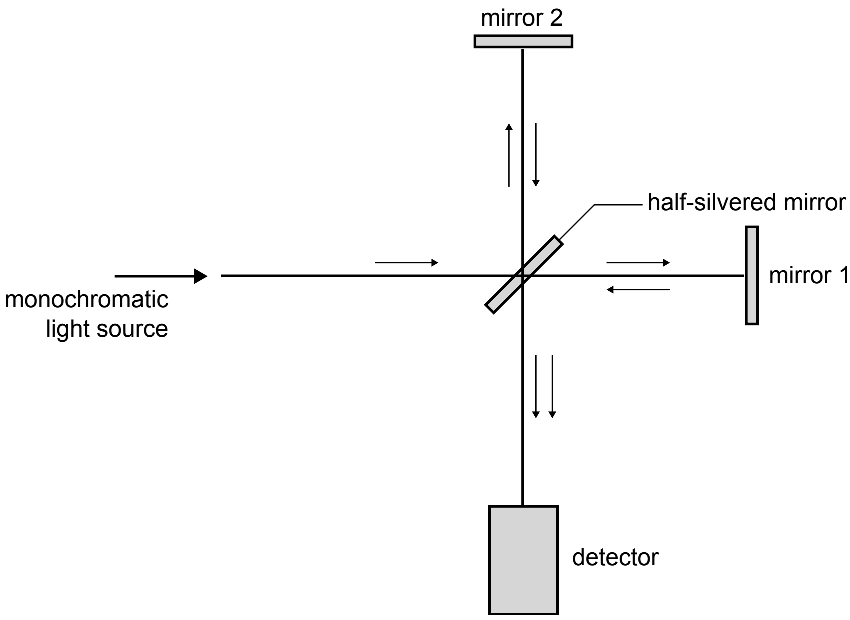


Figure 3

Question 6

Which one of the statements (**A.–D.**) specifies the critical basis of the apparatus?

A. The half-silvered mirror must reflect exactly half the light.

B. Mirror 1 and mirror 2 must be identical.

C. The distance travelled by light using either path must be equal.

D. The components must not move relative to each other.

2 marks

The apparatus was set up so that the light travelling towards mirror 2 was travelling perpendicular to the motion of Earth around the Sun, and the light travelling towards mirror 1 was in the direction of Earth's motion in its orbit. The measurement was then repeated with the apparatus turned through an angle of 90°.

Question 7

In the space below explain why this was done, and what results Michelson and Morley obtained.

3 marks

Question 8

Jason and Kylie are sitting at the northern and southern ends respectively of a train carriage travelling north at a high speed. Each holds a torch that they turn on and off. Harold is standing on a platform beside the train. As the midpoint of the carriage passes Harold, he observes simultaneous light flashes from both Jason and Kylie.

Which one of the following statements is true?

A. To an observer inside the carriage, located at its midpoint, Jason and Kylie turned on their torches at the same time.

B. To an observer inside the carriage, located at its midpoint, Jason turned on his torch before Kylie.

C. To an observer inside the carriage, located at the midpoint, Kylie turned on her torch before Jason.

D. It does not make any sense to ask in which order Jason and Kylie turned on their torches, because Einstein showed that time is relative.

2 marks

The electron accelerator at Stanford University is 3.2 km long (Figure 4). Electrons reach a velocity of 0.9999995 c, which means the Lorentz factor is 1000.

Figure 4

Question 9

For an electron travelling the length of the accelerator at this velocity, what would be the length of the accelerator in the electron's reference frame?

m

3 marks

Question 10

As measured by a scientist at the accelerator laboratory, how long would the electron take to travel the length of the accelerator?

s

2 marks

Question 11

How long would the electron measure its time of travel to be?

s

3 marks

END OF DETAILED STUDY 1

Detailed study 2 – Investigating structures and materials

Many buildings have foundations made of concrete, and the compressional strength of concrete is a critical factor in providing a firm foundation. Figure 1 shows the relationship between stress and strain for concrete. The points of failure are indicated by crosses.

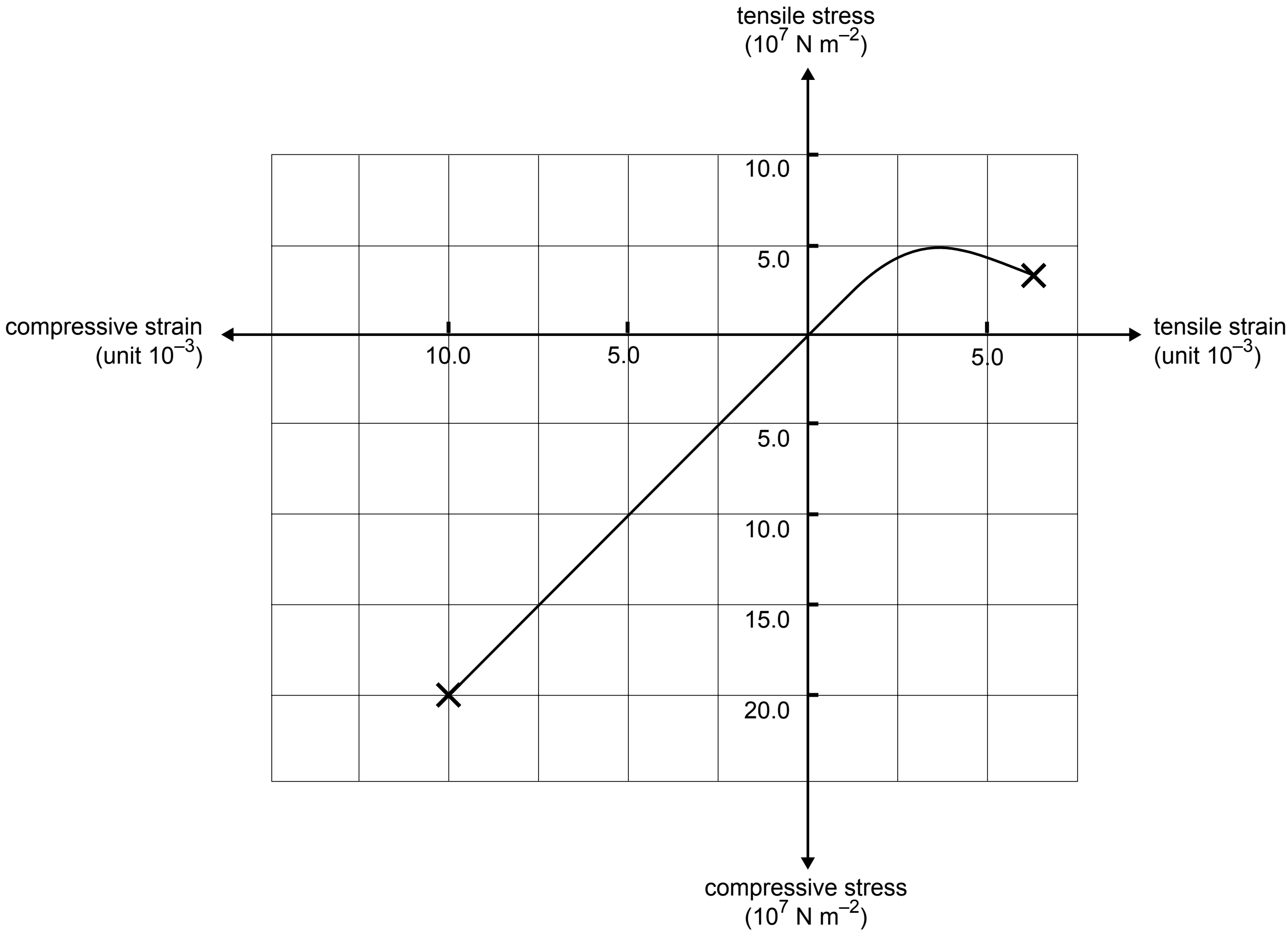


Figure 1

Question 1

What is the value of Young's modulus for concrete under **compression**?

A. 5.0×10^{-11} m^2 N^{-1}

B. 2.0 N m^{-2}

C. 2.5×10^7 N m^{-2}

D. 2.0×10^{10} N m^{-2}

2 marks

Along the Great Ocean Road one can see an architecturally notable house shown in Figure 2. It is built on a concrete slab that is supported by a concrete pillar.

The feasibility of such a structure depends critically on the compressional strength of concrete.

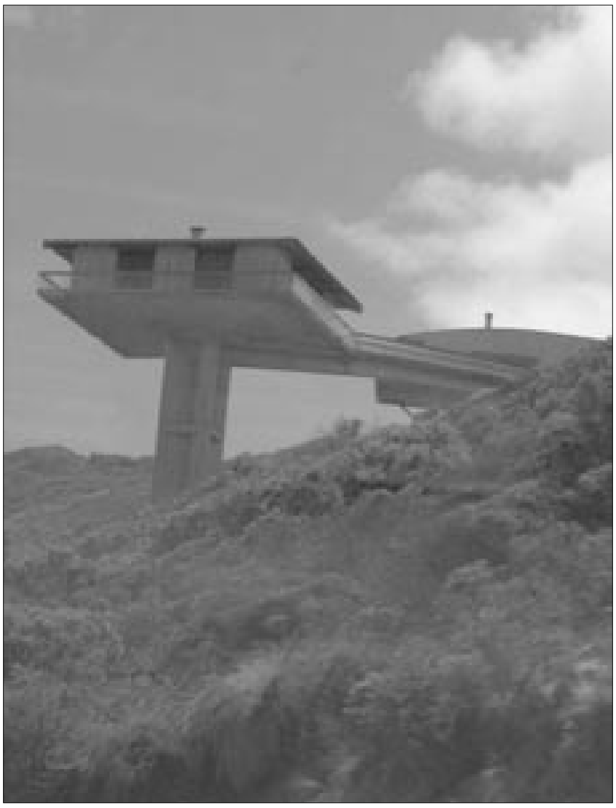


Figure 2

Consider such a structure, and assume the supporting pillar is approximately 8.0 m high and has a cross-sectional area of 2.0 m^2.

Question 2

What is the largest downward force such a concrete pillar can withstand without breaking?

N

3 marks

Question 3

Calculate the strain energy per unit volume stored in the concrete pillar **up to the point of fracture**.

J m^{-3}

2 marks

Question 4

By which of the following factors (**A.–D.**) would you multiply your answer to Question 3 to calculate the **total strain energy** stored in the concrete pillar **up to the point of fracture**?

A. 2
B. 8
C. 16
D. 32

2 marks

Because concrete is not strong under tension, it would not be safe to construct this house directly on a concrete slab. For this reason the slab is reinforced with steel rods.

Question 5

In the space below explain why steel is used as the material for the reinforcement rods.

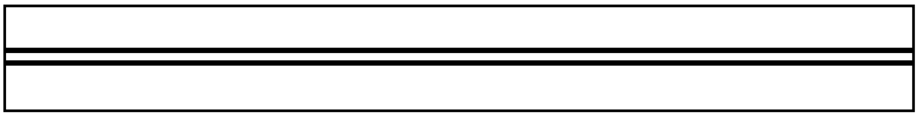
2 marks

Question 6

Which one of the sketches (**A.–D.**) shows the **best** placement of reinforcing steel rods in order to provide maximum strength for the concrete slab that supports the house? The steel reinforcements are represented by the thick black lines.

A.

B.



C.

D.

2 marks

Ultimately the strength of a material depends on intermolecular spacing on an atomic scale. The application of different stresses to a material results in a particular displacement of the atoms.

In Table 1 are listed three types of stress.

Table 1. Type of stress

A.	compressive
B.	tensile
C.	shear

Question 7

Below are statements that describe the displacement of the atoms resulting from the stresses in Table 1.

In each box, write the appropriate letter selected from Table 1 that describes the nature of the atomic displacement produced by the stress described.

The forces act to push adjacent layers of atoms close together. ☐

The forces act to slide adjacent layers of atoms over each other. ☐

The forces act to pull all atoms further apart. ☐

3 marks

The elastic properties of two materials, identified as X and Y, may be summarised as follows.

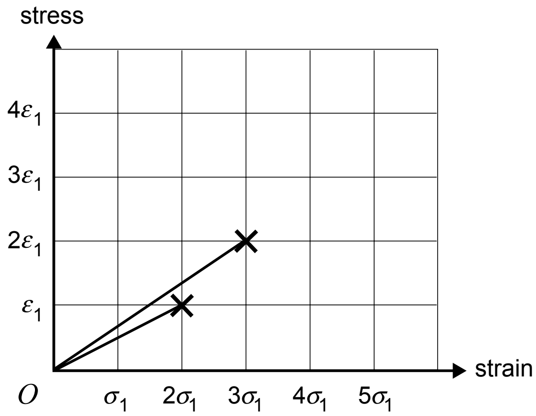
- X has twice the ultimate tensile strength of Y
- both X and Y undergo some plastic deformation before fracture
- X is three times tougher than Y, up to their point of fracture

Note: the points of failure are indicated on each graph by a cross **✕**

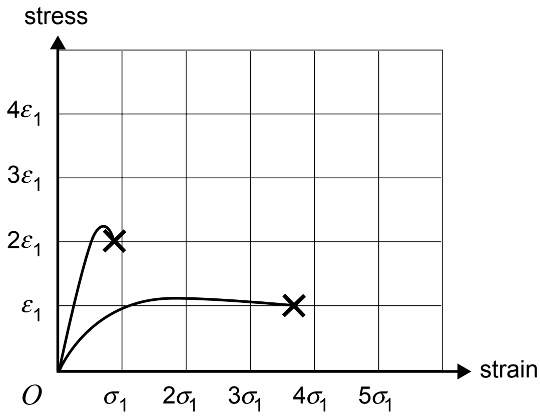
Question 8

Which one of the following stress-strain graphs (**A.–D.**) best represents the elastic properties of X and Y?

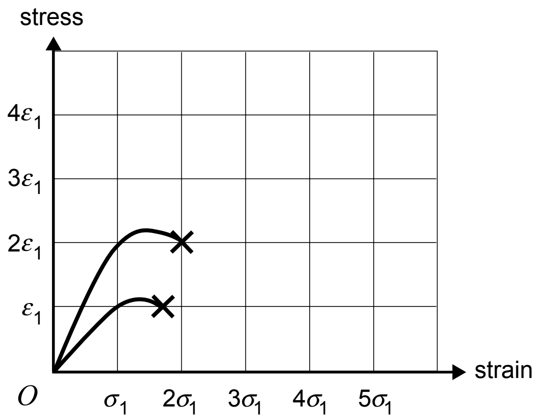
A.



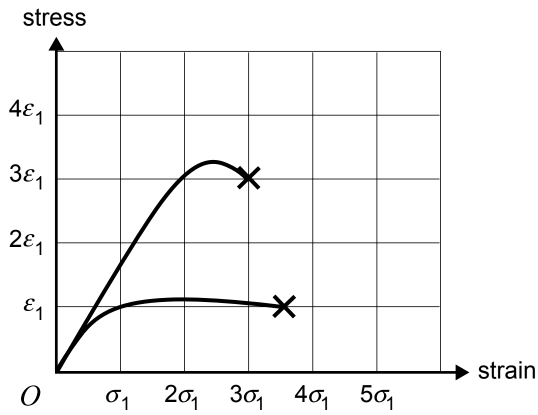
B.



C.



D.



2 marks

Question 9

Which one of the statements (**A.–D.**) indicates that material X is stiffer than material Y?

A. A greater stress is needed to fracture material X than material Y.

B. The gradient of the stress-strain curve is greater for material X than material Y.

C. The area under the stress-strain graph is greater for material X than for material Y.

D. Material X undergoes more plastic deformation than material Y.

2 marks

The North Canadian Indigenous Inuit used to build igloos to live in. Igloos are three-dimensional **arches** made from blocks of **ice**. Often, an additional low wall of ice blocks was built around the wall of the igloo touching the outer wall at the base of the igloo. This enables the igloo to stand for a long time. Figure 3 shows a cut-away diagram of an igloo.

Figure 3

Question 10

Consider the types of forces acting on the blocks of ice. What property of ice makes it a suitable material for the construction of the igloo?

2 marks

Question 11

Explain the properties of **arches**, and the features of an igloo, that ensure that it is a strong, safe and stable structure.

3 marks

Detailed study 3 – Further electronics

VCE students design and construct an AC to DC voltage-regulated power supply. This comprises the input from the domestic 240 V (RMS) mains supply, a transformer, a rectifying circuit, a smoothing circuit, a voltage regulator component and the load. The design is shown in Figure 1, where C is the capacitor, R_L is the load resistor. The Zener diode and R_V form a voltage regulator.

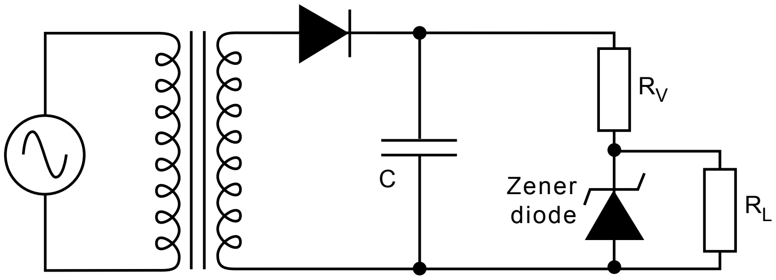


Figure 1

Question 1

Briefly state the essential meaning of each of the following three terms associated with a regulated DC power supply.

i. Rectification

____

____

ii. Smoothing

____

____

iii. Voltage regulation

____

____

3 marks

The design specifies a DC voltage across the load of 9 V, and so the Zener diode in Figure 1 is a 9 V Zener. The step-down transformer, when connected to the 240 V (RMS) mains AC supply, is designed to provide a sinusoidal output voltage of 24 V (peak-to-peak).

Question 2

There are a variety of step-down transformers to choose from.

Which one (**A.–D.**) should the students select to **best match** the design specifications in terms of voltage ratio?

An input/output voltage ratio of

A. 10:1

B. 14:1

C. 20:1

D. 28:1

2 marks

In order to understand the operation of the rectifying diode used in the circuit of Figure 1, the students wire up the circuit of Figure 2. In this circuit the rectified current, I_R, through the resistor is in the direction indicated.

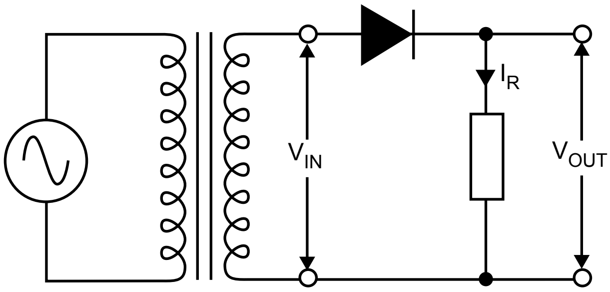


Figure 2

The students then use a cathode ray oscilloscope (CRO) to measure the input voltage, V_{IN}, and the output voltage, V_{OUT}, indicated in Figure 2. The input voltage is displayed in Figure 3a.

Question 3

On the blank CRO screen, Figure 3b, sketch the waveform you would expect at the output of the circuit of Figure 2. Assume the vertical and horizontal controls of the CRO are unchanged.

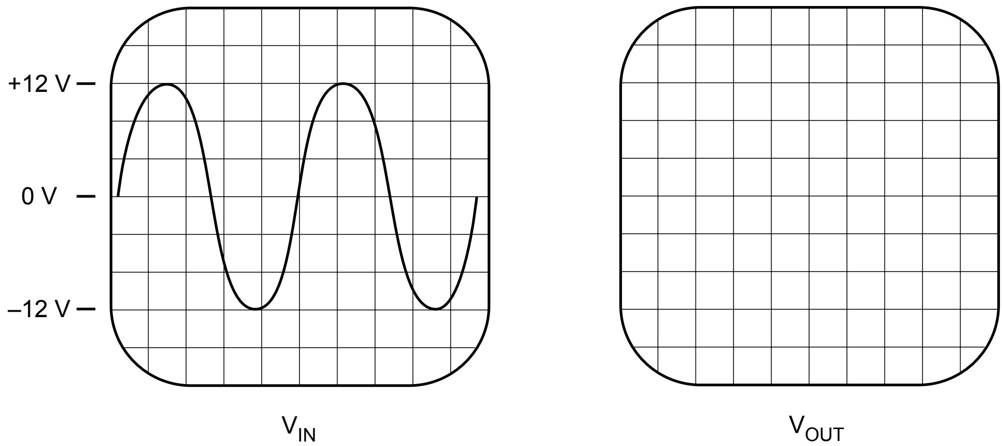


Figure 3a **Figure 3b**

2 marks

One of the students suggests that the single diode in Figure 2 be replaced by a full-wave rectifying bridge circuit.

Question 4

On the sketch of the incomplete circuit of Figure 4 (similar to the test circuit of Figure 2) draw in a full-wave bridge rectifier using **4 diodes** such that I_R is maintained in the direction indicated.

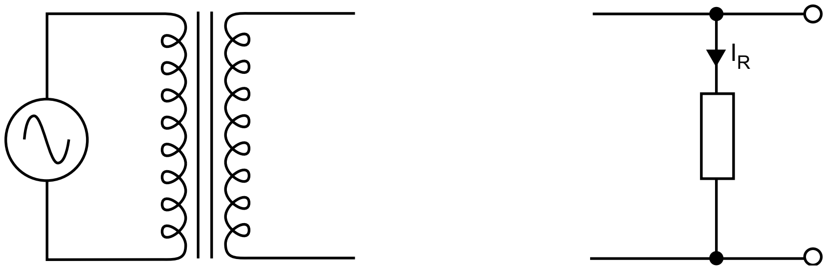


Figure 4

2 marks

The students decide not to use the bridge rectifier in the circuit and return to the original design of Figure 1. They next test the smoothing operation with a modified circuit shown in Figure 5 using C = 2000 μF, a switch, S, and a 100 Ω resistor. The switch is initially **open** so the resistor is disconnected at this time.

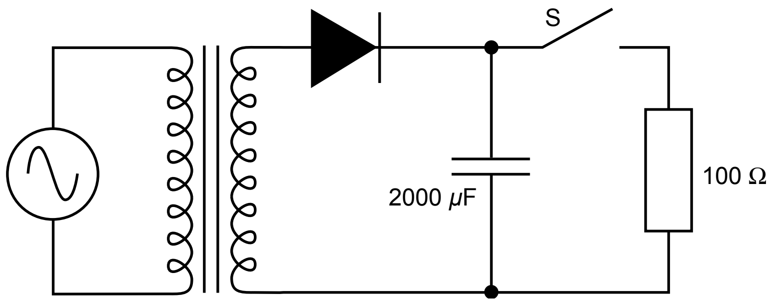


Figure 5

Question 5

The time constant of the circuit shown in Figure 5 is measured by the students to be 2 ms.

What is the effective forward resistance of the diode?

A. 0.1 Ω

B. 1 Ω

C. 2 Ω

D. 10 Ω

2 marks

The students now **close** the switch of the circuit of Figure 5, connecting the 100 Ω resistor into the circuit. The voltage across the 100 Ω resistor is measured using a CRO and is observed to comprise a DC component of about 12 V and an AC component, or ripple. They investigate this ripple by varying the values of some of the components in the circuit of Figure 5.

Question 6

Which one of the following statements (**A.–D.**) concerning the magnitude of the ripple voltage is correct?

A. It approximately doubles when the capacitance is halved to 1000 μF and the resistance doubled to 200 Ω.

B. It approximately doubles when the capacitance is doubled to 4000 μF and the resistance halved to 50 Ω.

C. It approximately doubles when the capacitance is halved to 1000 μF and the resistance left unaltered at 100 Ω.

D. It approximately doubles when the capacitance is doubled to 4000 μF and the resistance left unaltered at 100 Ω.

2 marks

The students now consider the final part of the design, the voltage regulator, using a resistor, R_V, in series with a 9 V Zener diode (see Figure 1).

The current-voltage characteristic of the Zener diode is shown in Figure 6.

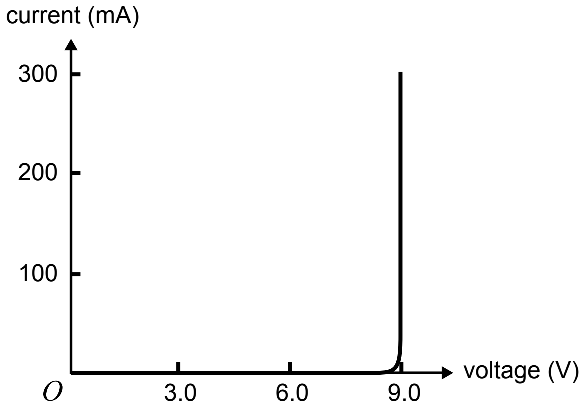


Figure 6

The students use a multimeter to measure the DC voltage across the 30 Ω resistor in Figure 1 to be approximately 3 V.

Question 7

Given that the voltage across the transformer is 24 V (peak-to-peak), in the space below explain why this value of 3 V across R_V is to be expected.

2 marks

Question 8

In this measurement for Question 7 the students could have used either a battery-powered multimeter (MM) or the mains-powered CRO.

Which one of the following statements concerning these two instruments is true?

A. The MM (in DC voltage mode) is the most sensible choice to measure this voltage across R_V compared to a CRO as it is less likely to affect the power supply circuit.

B. The CRO is the better voltage measuring instrument in this situation, as it can measure both the AC and DC voltages across R_V, while a MM can only measure DC voltages.

C. The MM is the better instrument to use as the only way to measure a current through a resistor is by using a MM (in AC or DC current mode). When using a CRO there is no way that the current in the resistor can be determined.

D. The CRO is the better instrument as it can be used to fully describe both the AC and DC voltages, while the MM cannot.

2 marks

Question 9

What is the power dissipated in the 30 Ω resistor, R_V, of Figure 1? Express your answer in mW.

mW

2 marks

The students now have a fully operational regulated 9 V DC power supply as shown in Figure 1. The final circuit has C = 2000 μF, a 9 V Zener diode regulator and R_V = 30 Ω. To start with, the students connect a load resistor of R_L = 300 Ω. They then do a series of tests to observe what might change the output DC across the load resistor.

Question 10

Based on their observations, which one of the following statements (**A.–D.**) is correct?

A. The output DC voltage changes if the mains supply voltage is increased to 250 V (RMS).

B. The output DC voltage changes if the load resistor is increased to 400 Ω.

C. The output DC voltage changes if the 9 V Zener diode is replaced by a 6 V Zener diode.

D. The output DC voltage changes if the capacitor is increased to 3000 μF.

2 marks

Question 11

The students have their circuit checked by a qualified electrician who advises them that their power supply circuit will require a heat sink. Explain why a heat sink is used in this regulated power supply circuit, and what part of the circuit needs to be attached to this heat sink.

2 marks

As a final part of their project to design and construct a regulated DC power supply, the students have to write a brief report. Students discuss safety and risk associated with this project.

Question 12

Which is the most important activity to ensure maximum safety and minimum risk?

A. learning from trial and error when designing and constructing electrical circuits

B. getting the teacher (or someone appropriately qualified) to check each stage of the design and construction

C. understanding how to correctly use a cathode ray oscilloscope and a multimeter for troubleshooting and diagnosis

D. understanding the physics of specific components such as the transformer, diodes, capacitor and resistor

2 marks

END OF QUESTION AND ANSWER BOOK