THE SCHOOL FOR EXCELLENCE (TSFX)

UNIT 3 PHYSICS 2007

WRITTEN EXAMINATION 1

Reading Time: 15 minutes
Writing Time: 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 Studies**			
	Motion	17	17	35
	Electronics and Photonics	15	15	30
B	**Detailed Studies**			
	1. Einstein's Special Relativity **OR**	10	10	25
	2. Further Electronics **OR**	11	11	25
	3. Structures and Materials	10	10	25
				Total 90

COMPLIMENTS OF THE SCHOOL FOR EXCELLENCE

Voted Number One For Excellence and Quality in VCE Programs and Tutorials.

THE SCHOOL FOR EXCELLENCE (TSFX)

The School For Excellence (**TSFX**) is a private educational institution that provides educational services to Year 11 and 12 students out of school hours. Our services include intense revision courses before examinations, intense weekly tuition classes, study skills lectures, as well as specialised courses that prepare students in advance of each school term.

The educational programs conducted by **TSFX** are widely recognised for providing the highest quality programs in Victoria today. Our programs are the result of more than 15 years of collaborative effort and expertise from dozens of teachers and schools across the state, ensuring the highest possible quality resources and teaching styles for VCE students.

For additional information, join our complimentary mailing list at **www.tsfx.com.au**.
Alternatively, please call **TSFX** on (03) 9663 3311 during business hours.

FREE VCE RESOURCES AT VCEDGE ONLINE

VCEdge Online is an educational resource designed to provide students the best opportunities to optimise their Year 11 or 12 scores. **VCEdge Online** members receive over $300 worth of resources at no charge, including:

- Subject notes and course summaries.
- Sample A+ SACS and SATS.
- Trial examinations with worked solutions.
- Weekly study tips and exam advice (in the weeks leading up to the examinations)
- Two **FREE** tickets into an intense examination strategy lecture (valued at $200!!!).
- Cheat sheets and formula cards.
- Critical VCE updates.
- Free VCE newsletters.
- Information on upcoming educational events.
- And much, much more!!!

JOIN FREE OF CHARGE AT WWW.TSFX.COM.AU

SECTION A – CORE STUDIES

Instructions For Section A

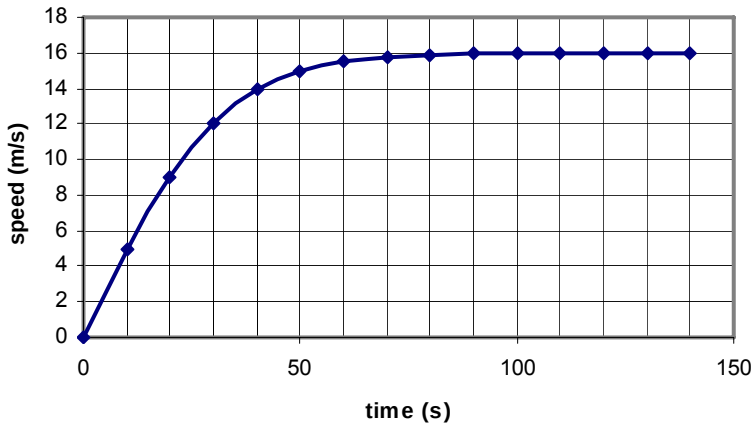
Answer **all** questions for **both** Areas of Study in this section of the paper.
You should take the value of g to be $10\ ms^{-2}$.
Unless stated otherwise, ignore air resistance.

AREA OF STUDY 1: MOTION IN ONE AND TWO DIMENSIONS

Questions 1 to 4 refer to the following information:

From a stationary start, Emily rides her bike in a time trial along a straight path. She maintains her maximum driving force of 40 N for the entire trial and reaches a maximum speed of 16 m/s after 90 seconds, which is then maintained. The combined mass of Emily and her bike is 70 kg. Her speed-time graph is shown as Figure 1.

Figure 1



QUESTION 1
What was Emily's maximum speed in kilometres per hour?

_____

_____

_____

1 mark

km/hr

QUESTION 2
What was the magnitude of the net force on Emily after 120 seconds?

1 mark

N

QUESTION 3
Estimate how far Emily travelled in the first 50 seconds.

2 marks

m

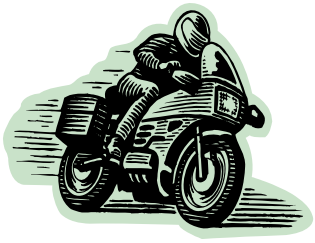
QUESTION 4
What is the magnitude of the sum of the resistance forces acting against her after 30 seconds if her acceleration at that time was 0.24 m/s^2?

3 marks

N

Questions 5 and 6 refer to the following information:

A motorbike and rider have a combined mass of 320 kg. They follow a circular pathway in changing their direction from heading south to heading east. The circular pathway has a radius of curvature of 24 metres and the maximum frictional force between the wheels of the bike and the surface is 1920 N.



QUESTION 5
With the frictional force solely providing the centripetal force, what is the maximum speed with which the bike and rider can change direction in this way?

_____

_____

_____

_____

2 marks

	m/s

QUESTION 6
When exactly half way around the bend, what will be the direction of the horizontal component of the force of the **motorbike on the surface**?

A. South-east
B. South-west
C. North-east
D. North-west
E. West

2 marks

Questions 7 and 8 refer to the following information:

A car passes a bus (at time $t = 0\ s$) and they are both heading west. The car is traveling at 20 m/s and the bus is moving at 15 m/s.

QUESTION 7

What is the relative velocity of the **car** relative to the bus?

2 marks

Magnitude:	m s^{-1}

Direction:

QUESTION 8

At time $t = 6\ s$, what is the displacement of the **bus** relative to the car?

2 marks

Magnitude:	m

Direction:

Questions 9 to 13 refer to the following information:

Playing cricket in the park with her friends, Toni hits a tennis ball such that it leaves the bat with an initial speed of 26 m/s. The ball is caught by a fielder at the same height above the ground as it was hit and during its trajectory, the ball reaches a maximum height of 5.0 m above its initial height.
(Ignore air resistance, g = 10 m/s^2)

QUESTION 9
What must have been the vertical component of the initial velocity of the ball?

2 marks

m/s

QUESTION 10
For how long was the ball in its trajectory?

2 marks

s

QUESTION 11
Approximately how far from the bat was the fielder?

3 marks

m

QUESTION 12
What was the initial angle of inclination of the hit ball?

_____

_____

_____

_____

_____

_____

3 marks

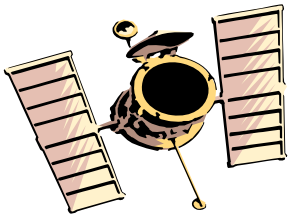
degrees

QUESTION 13
In alternatively considering the trajectory of the ball **in air** and allowing for air resistance, which of the following would now be true?

A. The ball would be in the air for slightly longer.
B. The ball would travel further.
C. The ball would reach a greater maximum height.
D. The ball would reach the fielder at a speed greater than 26 m/s.
E. None of the above.

2 marks

Questions 14 to 17 refer to the following information:



The geostationary satellite ASTRA 1H was launched in 1999 and at an altitude of 35,786 km ASTRA 1H serves Europe in internet access.

(Mass of Earth = 5.98×10^{24} kg, Radius of Earth = 6.38×10^{6} m)

QUESTION 14
What is the orbiting speed of ASTRA 1H?

_____

_____

_____

_____

2 marks

	m/s

QUESTION 15
What is the orbital period of ASTRA 1H?

_____

_____

_____

_____

2 marks

	s

QUESTION 16
What is the gravitational field strength where ASTRA 1H is orbiting?

_____

_____

_____

_____

2 marks

	N/kg

QUESTION 17
Which of the following contributes greatest to the orbital motion of ASTRA 1H?

A. ASTRA's rockets.
B. ASTRA's spin.
C. ASTRA's solar panels and motor.
D. The sun
E. The earth

2 marks

End of Section on Motion in One and Two Dimensions

AREA OF STUDY 2: ELECTRONICS AND PHOTONICS

Figure 1 shows a thermistor being used in a voltage divider that controls the switching of a home heating system. ***The unit turns off when V_{OUT} is 6V.***

Figure 1

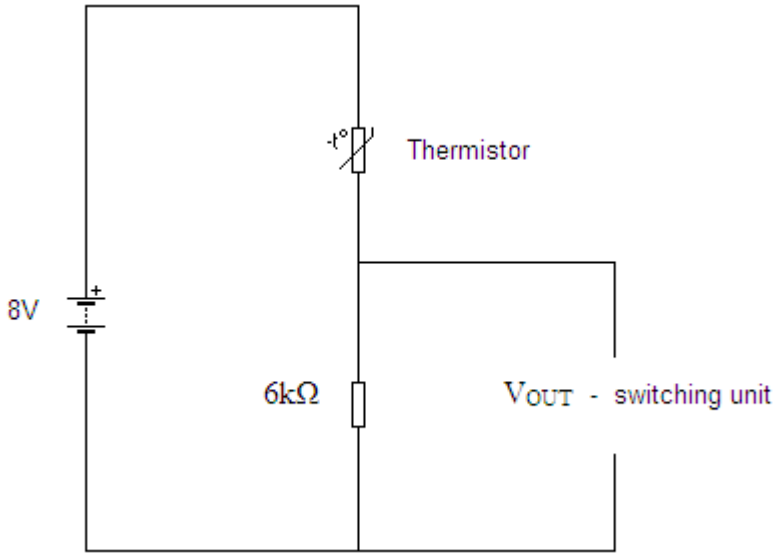
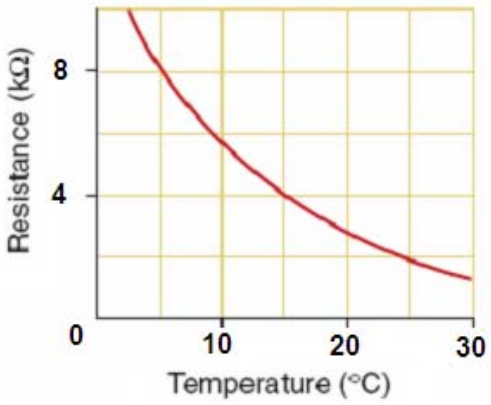


Figure 2 shows the resistance characteristics of the thermistor.

Figure 2



QUESTION 1
Determine the temperature at which the unit switches off.

_____

_____

2 marks

^{o}C

QUESTION 2
Calculate V_{OUT} when the temperature is 15^{o}C.

_____

_____

_____

_____

2 marks

V

QUESTION 3
The switching unit was originally designed to turn on when V_{OUT} is 6.0V or more, however, on testing it was found that the reverse occurred. ie. the heating unit turned off when the temperature dropped below a certain value and V_{OUT} was less than 6.0V. Suggest a modification to the circuit in figure 1 that would enable it to operate correctly.

_____

_____

_____

_____

_____

2 marks

QUESTION 4
Suggest another modification that would enable different users to be able to select different temperatures at which the unit would switch the heating on.

_____

_____

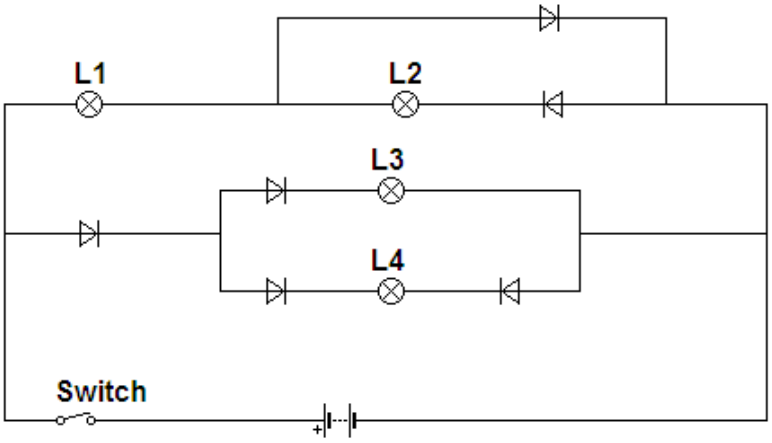
_____

_____

_____

2 marks

QUESTION 5



Which lamps will light up when the switch is closed?

A. L_1, L_3, L_4
B. L_1, L_2, L_3
C. L_1, L_3
D. L_3, L_4

2 marks

QUESTION 6

A voltmeter is placed across a power diode as shown in Figure 3 below. Figure 4 shows the current – voltage characteristics of the diode.

Figure 3

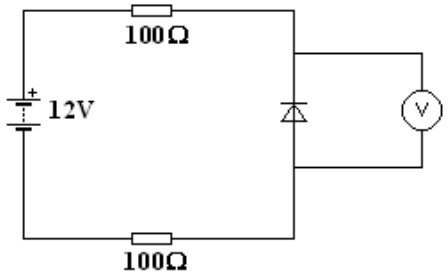
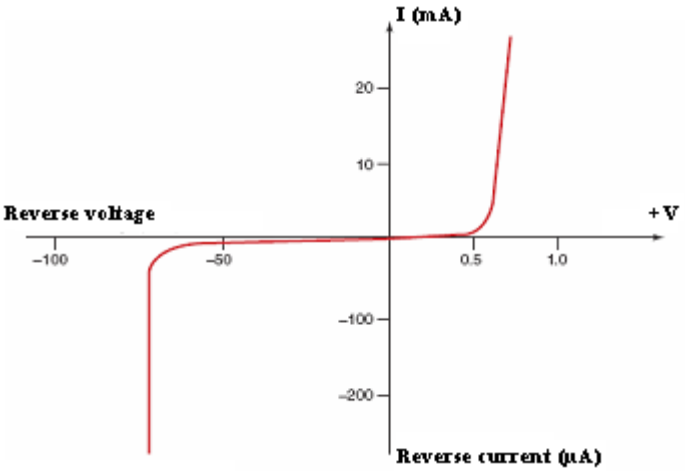


Figure 4



The voltmeter is likely to read a value of approximately:

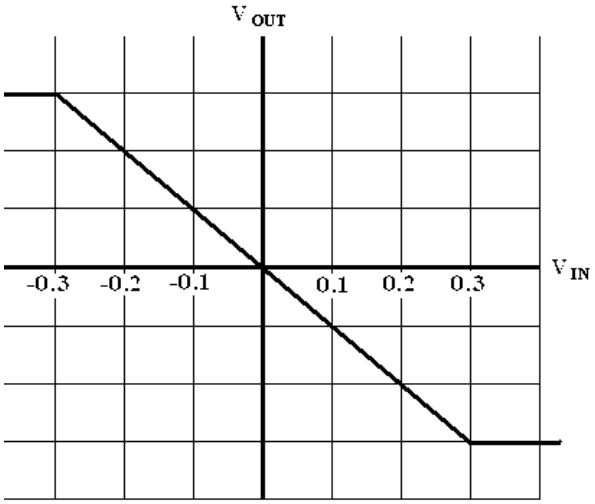
A. 0 volts
B. 0.7 volts
C. 11.3 volts
D. 12 volts

2 marks

The characteristics of a voltage amplifier are shown in the following $V_{OUT} – V_{IN}$ graph.

QUESTION 7
The amplifier has a gain of ten. Fill in the scale values for V_{OUT}.

Figure 5



2 marks

QUESTION 8
Is this an inverting or non-inverting amplifier? Explain your choice.

_____

_____

_____

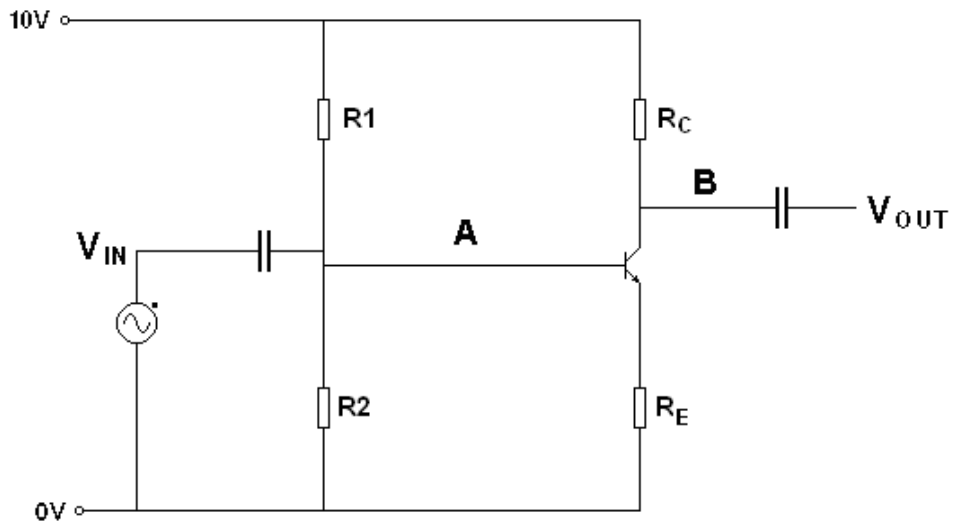
_____

_____

2 marks

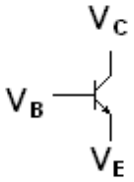
The following information applies to Questions 9 to 12:

Figure 6



It is desired that with no V_{IN} signal

- V_C is 5.0 V
- V_E is 0.3 V
- V_{BE} is 0.7 V
- The base current is 10 μA.



QUESTION 9

With no V_{IN} signal, what is the voltage at the base pin?

_____

_____

_____

_____

2 marks

V

QUESTION 10
The npn transistor is biased using two voltage divider resistors, R_1 and R_2, and a +10 V supply voltage. If resistor of 36 kΩ is used for R_1, an appropriate value for R_2 would be:

A. 1800Ω
B. 4000Ω
C. 6kΩ
D. 360kΩ

2 marks

QUESTION 11
If there is an increase in base voltage of 0.1V, what will be the voltage at the collector pin of the transistor?

2 marks

V

QUESTION 12
The increase in base voltage of 0.1V was accompanied by an increased base current of 2.0 μA. What is the current gain of the amplifier?

2 marks

The following information applies to Questions 13 to 15:

The diagram below shows the I-V characteristics of a photodiode connected into a circuit.

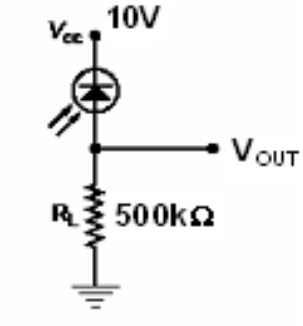
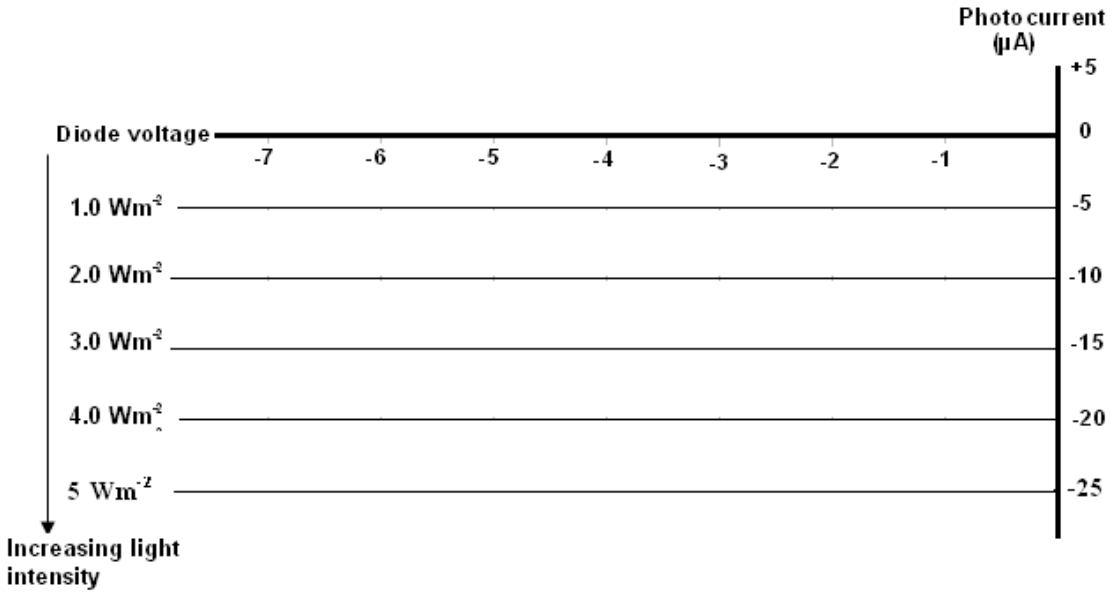


Figure 7



QUESTION 13

Determine the maximum current that can flow through R_L.

2 marks

	μA

QUESTION 14
Determine the maximum light intensity that can be reliably measured by the circuit.

_____

_____

_____

_____

2 marks

Wm^{-2}

QUESTION 15
What is the value of V_{OUT} when the light intensity is 1.0 Wm^{-2}?

_____

_____

_____

_____

2 marks

V

End of Electronics and Photonics Section

SECTION B – DETAILED STUDIES

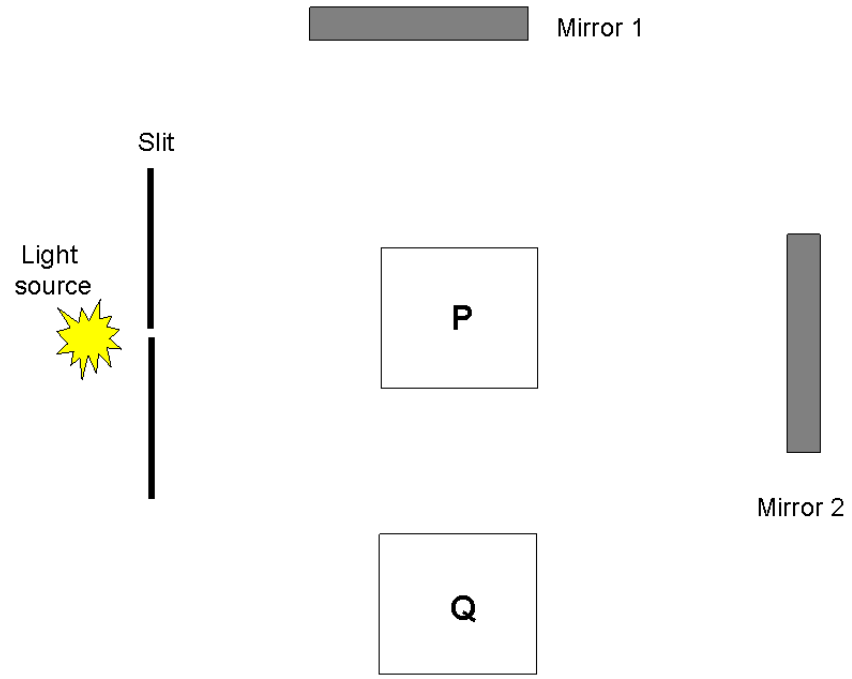
Instructions For Section B

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

DETAILED STUDY 1 – EINSTEIN'S SPECIAL RELATIVITY

Figure 1 is a representation of the apparatus used in the Michelson-Morley experiment.

Figure 1



QUESTION 1
Which of the following answers (A-D) best describes the equipment pieces P and Q shown in Figure 1?

	P	Q
A.	Half-silvered mirror	Prism
B.	Half-silvered mirror	Light detector
C.	Telescope	Prism
D.	Prism	Half-silvered mirror

2 marks

QUESTION 2
On Figure 1 on the previous page, draw the path of the light emitted from the source indicating the direction the light travels.

3 marks

QUESTION 3
A rocket ship is travelling close to the speed of light past the Earth from left to right and observes two flashing lights directly below. To an observer on the Earth, the lights are flashing simultaneously. Which of the following observations made by the people on the rocket (A-D) is true?

A. The lights are flashing simultaneously.
B. The left light flashes first.
C. The right light flashes first.
D. It is impossible to determine without knowing the speed of the rocket.

2 marks

The following information applies to Questions 4 and 5:

A spaceship travels away from the Earth at a relative speed of 0.7c.
10 years have elapsed on Earth.

QUESTION 4
Which of the following possibilities (A-D) shows how many years have elapsed on the spaceship according to an observer on the Earth and, given this, how many years have elapsed on the Earth according to an observer on the spaceship?

	Number of years elapsed on spaceship according to the Earth observer	Number of years elapsed on Earth according to the spaceship observer
A.	10	10
B.	7.1	10
C.	7.1	7.1
D.	7.1	5.1

2 marks

QUESTION 5
If the spaceship turns around and travels back to Earth at the same speed, 20 years have lapsed from the point of view of the Earth. If both the Earth and spaceship observers were 30 years old when the spaceship left, what is the age of both observers after the ship returns?

2 marks

Earth Observer:	years

Spaceship Observer:	years

The following information applies to Questions 6 to 9:

An electron has a rest mass of 9.11×10^{-31} kg in a laboratory. When accelerated to a relativistic speed the electron has a mass of 2.09×10^{-30} kg.

QUESTION 6
Determine the speed of the electron in terms of c.

2 marks

QUESTION 7
Determine the total energy of the electron in Joules.

2 marks

J

QUESTION 8
Show that the kinetic energy of the electron at this speed is 0.66 MeV.
(*You must show all working*).

3 marks

The following information applies to Questions 9 and 10:

A muon is created when cosmic rays from the sun reach the atmosphere. The Earth's atmosphere reaches 10 km above the surface. The muon travels through the Earth's atmosphere at 0.9995c and is able to reach the surface despite its small half-life of 2.2 μs as measured in a laboratory.

QUESTION 9
Explain how the muon is able to reach the Earth's surface. Provide support for your argument with calculations.

4 marks

QUESTION 10
Explain, in terms of mass, why an object is unable to travel at the speed of light.

_____

_____

_____

_____

_____

_____

_____

_____

_____

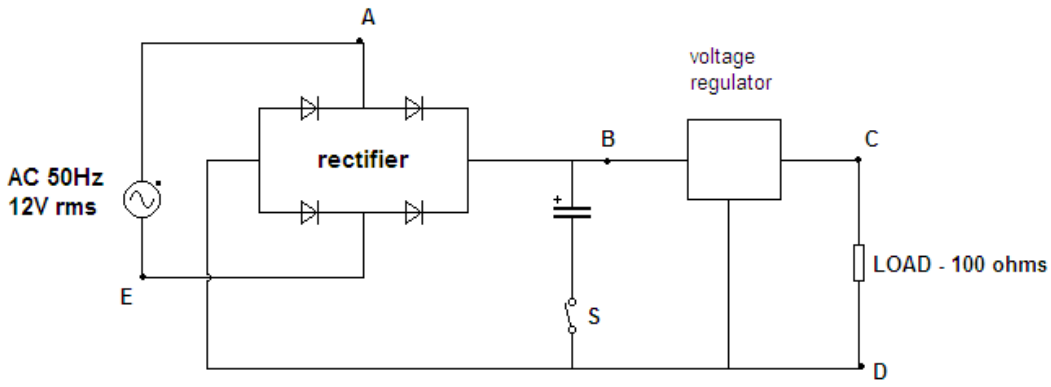
_____

3 marks

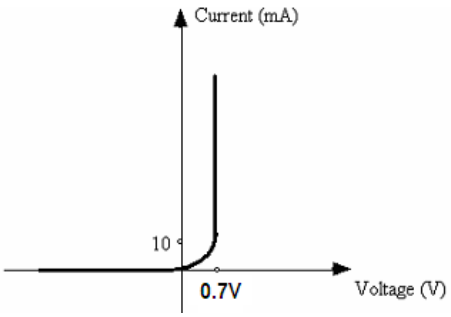
End of Einstein's Special Relativity Section

DETAILED STUDY 2 – FURTHER ELECTRONICS

The following circuit was constructed to provide a ***regulated DC power supply***. It uses a 10 volt IC voltage regulator in order to maintain an appropriate voltage to a 100 ohm load.



The bridge rectifier consists of four IN4004 silicon-based power diodes with the following current-voltage characteristics.



A small capacitor was incorporated in order to reduce the peak-to-peak V_{RIPPLE} to 3.0 volts at the voltage regulator when switch S is closed.

QUESTION 1
In this context, what is the meaning of the words **'regulated DC power supply'**?

_____

_____

_____

_____

_____

2 marks

QUESTION 2
In the following question, sketch the signal that would be obtained if a cathode ray oscilloscope (CRO) was placed across the following points. Actual values are not required.

(a) A-E

1 mark

(b) B-D when switch S is open.

1 mark

(c) CD when switch S is closed.

1 mark

QUESTION 3
Calculate the peak voltage that would be received at the voltage regulator.

_____

_____

_____

_____

2 marks

V

QUESTION 4
Estimate the power dissipation across the voltage regulator. Explain your reasoning.

_____

_____

_____

_____

2 marks

W

QUESTION 5
A second identical load is now placed in parallel across the original load. What effect will this addition to the circuit have on energy dissipation across the voltage regulator?

A. No change.
B. Double.
C. A little less than double.
D. A little more than double.

2 marks

QUESTION 6
What are the consequences of the voltage regulator getting too hot?

_____

_____

_____

_____

2 marks

QUESTION 7
Suggest two methods that could be used to minimise overheating of the voltage regulator.

_____

_____

_____

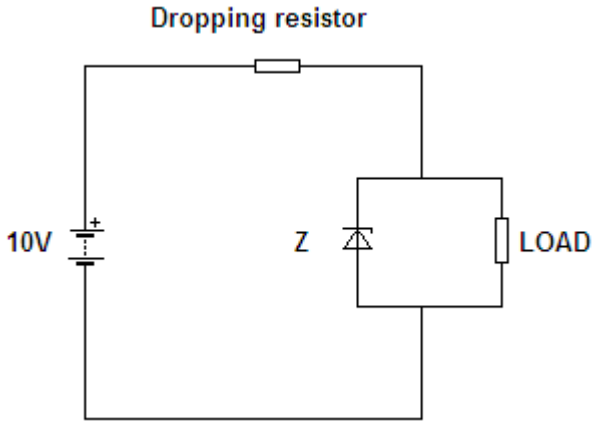
_____

_____

2 marks

The following information applies to Questions 8 to 10:

A zener diode (Z) with a breakdown voltage of 6.0 V and a load, is placed in a circuit with a voltage dropping resistor connected to a 10 V DC supply.



This circuit is to supply a constant 200 mA current.

QUESTION 8
What value should be used for the dropping resistor?

_____

_____

_____

_____

2 marks

	Ω

QUESTION 9
If the load resistor is 40Ω, how much current would pass through the zener diode?

_____

_____

_____

_____

2 marks

A

QUESTION 10
The zener diode used in the circuit has a power rating of 400mW. Is this a suitable choice of diode for the intended circuit? Justify your answer.

_____

_____

_____

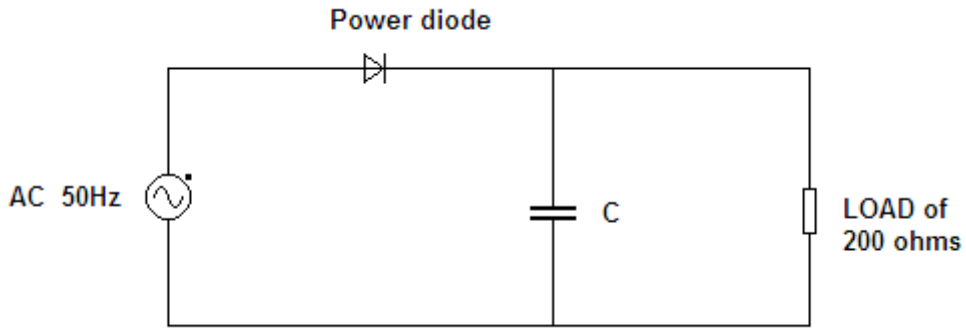
_____

_____

_____

3 marks

QUESTION 11
A 200 ohm load is connected to a 50Hz AC power supply as shown. The peak voltage of the supply **across the LOAD** is 12V.



Using a capacitor with a time constant five times longer than the period of the supply gives a ripple voltage about 20% of V_{peak}. This is ideal for the LOAD application in this circuit.

What value capacitor should be used? Show your working.

3 marks

μF

End of Further Electronics Section

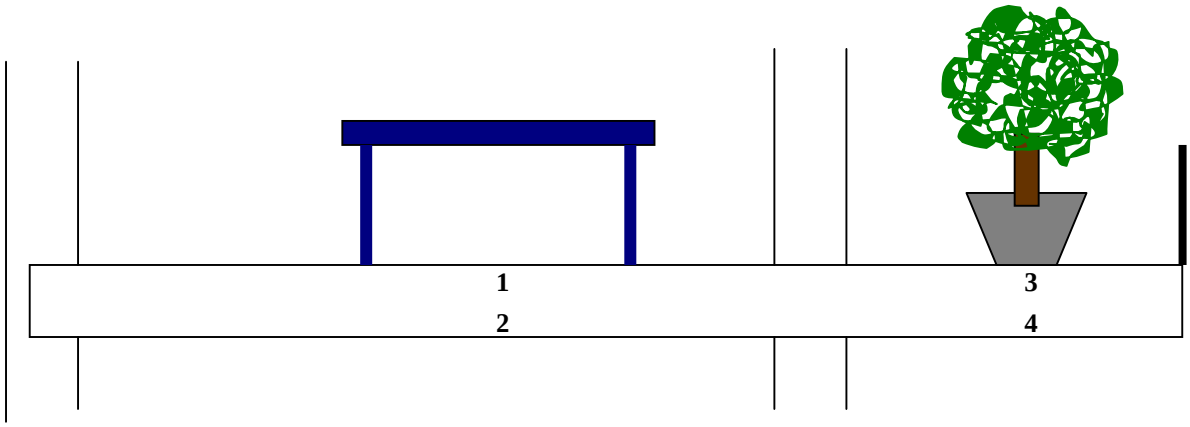
DETAILED STUDY 3: MATERIALS AND STRUCTURES

Questions 1 and 2 refer to the following information:

The floor of an apartment extends to become the balcony as illustrated in Figure 1. Inside the apartment is a large dining table and chairs. The balcony is essentially a cantilever and carries a heavy pot plant. The floor and balcony are made of concrete and the builder has two pieces of thick steel mesh to use as reinforcing.

Possible positions for the steel within the concrete are labelled 1, 2, 3 and 4.

Figure 1



QUESTION 1
Which is the best option for positioning the steel in the concrete?

A. 1 & 2
B. 1 & 3
C. 1 & 4
D. 2 & 3
E. 2 & 4
F. 3 & 4

2 marks

QUESTION 2
Explain why steel or iron can be used for reinforcing of concrete and why most steel is better than iron for this purpose.

2 marks

Questions 3 to 6 refer to the following information:

A roof beam of negligible mass, with the dimensions shown in Figure 2, is entirely supported by a narrow, central pole. The roof beam is then attached to the wall of a building but as shown in Figure 2, exerts **no force** on the wall.

Two children (40 kg & 30 kg) climb onto the roof beam and safely sit on it as shown in Figure 3. Their distances from the wall are shown. The roof beam now applies a force to the wall.

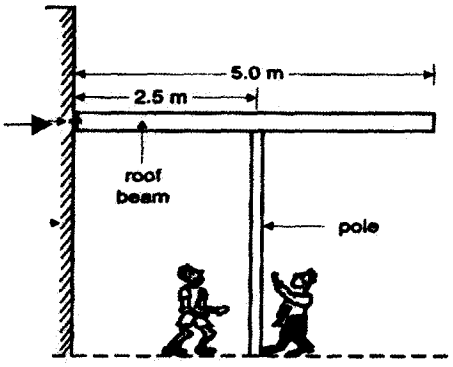


Figure 2

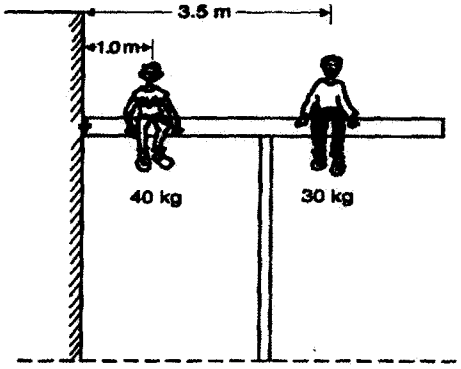


Figure 3

QUESTION 3
Which of the following (A-D) **best** describes the direction of the force that the roof beam applies to the wall in Figure 3?

A. Upwards
B. Downwards
C. To the left
D. To the right

2 marks

QUESTION 4
Calculate the size of the force on the wall resulting from the children sitting on the roof beam as in Figure 3.

3 marks

N

QUESTION 5
Calculate the size of the support force of the pole when the children are sitting on the roof beam as in Figure 3.

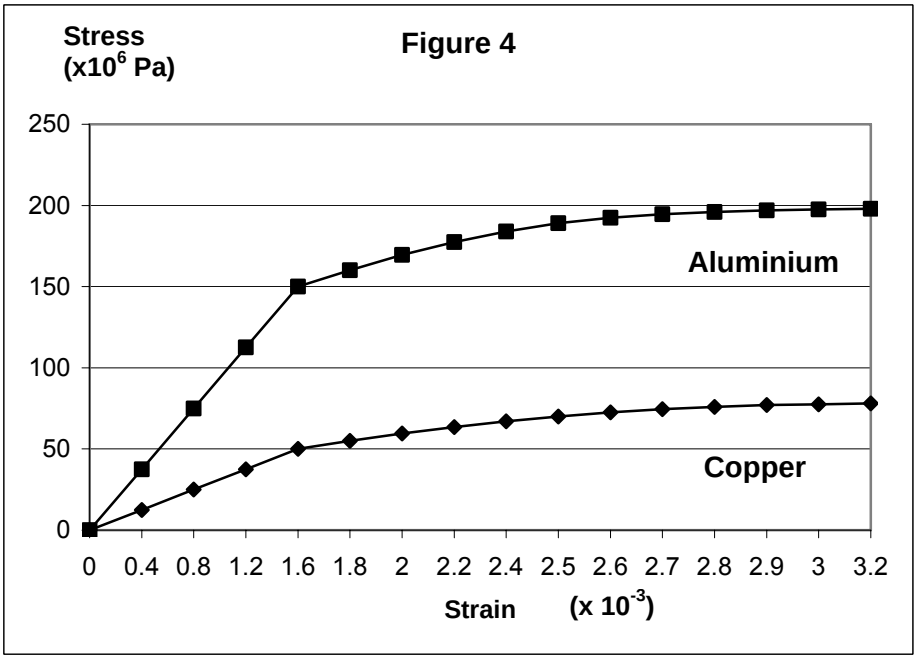
3 marks

N

QUESTION 6
If the 40 kg child was to move along the beam to be closer to the supporting pole, which of the following is true for *the Force of the wall on the roof beam* **and** *the size of the support force provided by the pole*?

A. Both would increase.
B. Both would decrease.
C. One would decrease and the other would increase.
D. Both would remain the same.

2 marks



QUESTION 7

The stress-strain graphs for both Aluminium and Copper are shown in Figure 4. In choosing Aluminium over Copper for a machine part, an engineer stated that Aluminium is stronger and tougher than Copper. Explain what she meant and how the graph supports her statement.

4 marks

Questions 8 to 10 refer to the following information:

The stress-strain graph for a square-ended beam of iron is shown in Figure 5 and the beam is illustrated in Figure 6.

Figure 5

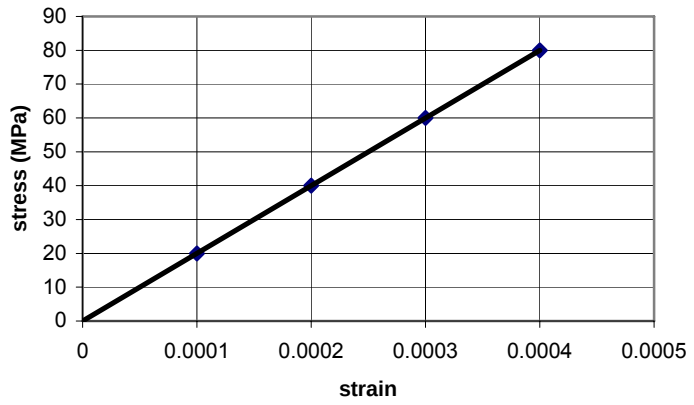
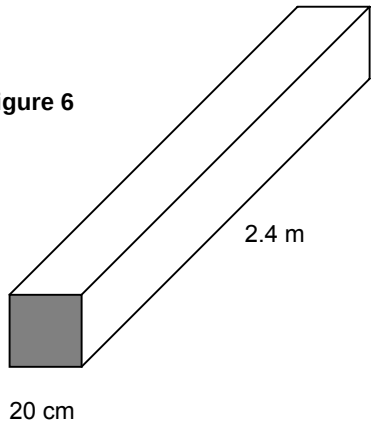


Figure 6



QUESTION 8

Calculate Young's Modulus for this iron.

2 marks

Pa

QUESTION 9
Calculate the strain energy per unit volume for this iron beam when it is experiencing a stress of 60 MPa.

3 marks

J/m^3

QUESTION 10
How much will this beam compress when a compressive load of 1.0×10^6N is applied to the ends of the beam? (Answer in mm).

2 marks

mm

End of Structures and Materials Section