Student Name: _____

PHYSICS

Unit 3 – Written examination 1

2008 Trial Examination

Reading Time: 15 minutes
Writing Time: 1 hour and 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	19	19	39
2. Electronics and Photonics	14	14	25
B-Detailed Studies			
1. Einstein's Special Relativity	13	13	26
OR			
2. Investigating Structures and Materials	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, and rulers, up to two pages of pre-written notes and a 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 22 pages.
- Section B Multiple Choice Answer Page
- Standard formula sheet

Instructions

- Print your name in the space provided on the top of this page.
- Responses to Section B must be completed on the Multiple Choice Answer Page in pencil.
- All written responses must be in English.
- Write your answers in the spaces provided.
- Where an answer box has a unit printed in it, give your answer in that unit.

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

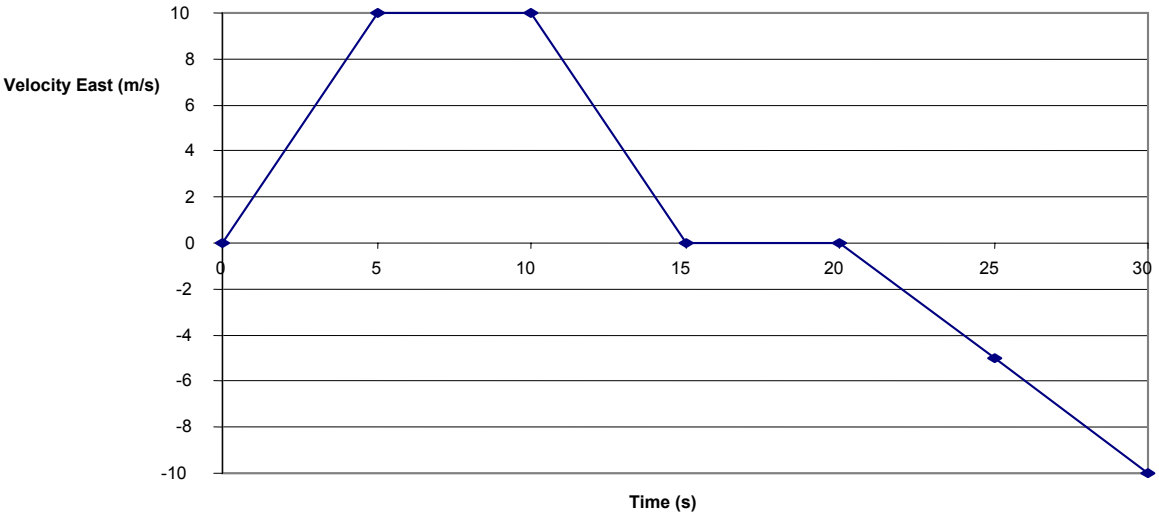
SECTION A – Core

Instructions for Section A
Answer **all** questions **for both** Areas of Study in this section of the paper.
Take the value of g to be 10 ms^{-2}
Always show working out where space is provided.

Area of Study 1- Motion in one and two dimensions

The velocity of a cyclist is recorded as a function of time in **Figure 1** below for a 30 second journey. The mass of the bicycle and rider is 90 kg.

Figure 1:



Question 1
Calculate the total distance travelled by the cyclist after 30 seconds.

_____

1 mark

Question 2
Calculate the displacement of the cyclist after 30 seconds.

_____

1 mark

Question 3
Calculate the average velocity of the cyclist over the 30 second time interval.

_____

2 marks

SECTION A – AREA OF STUDY 1 – continued

Question 4
Calculate the net force on the cyclist at $t = 25$ seconds.

_____

_____

2 marks

Gavin is at the golf driving range. He selects a club that will launch the ball at an angle of 60° to the horizontal. Gavin strikes the ball with a launch speed of 50 m/ s. The ball lands at the same elevation that it leaves the ground
The effects of air resistance on the ball can be ignored for **Questions 5, 6 and 7**.

Question 5
Calculate the total time of flight of the ball.

_____

_____

_____

3 marks

Question 6
Calculate the horizontal range of the ball.

_____

_____

2 marks

Question 7
Calculate the acceleration of the golf ball at the top of its flight.

_____

1 mark

Question 8
If the effects of air resistance are significant what would happen to the horizontal range of the ball?

_____

1 mark

SECTION A – AREA OF STUDY 1 – continued
TURN OVER

A red ball of mass 30 g and travelling at speed of 3 m/ s East strikes a stationary blue ball of mass 80 g. After the collision the red ball rebounds off the blue ball towards the West. The velocity of the blue ball after the collision is 1.5 m/ s East. The time of the collision is 0.15 s. Assume the collision can be considered isolated.

Question 9
Calculate the velocity of the red ball after the collision.

_____

_____

_____

_____

_____

3 marks

Question 10
Calculate the average force exerted by the red ball on the blue ball during the collision.

_____

_____

_____

_____

_____

3 marks

Question 11
Is this an elastic or inelastic collision? Justify your answer with an appropriate calculation.

_____

_____

_____

3 marks

SECTION A – AREA OF STUDY 1 – continued

Mars has a mass of $6.42 \times 10^{23} kg$ and radius of 3400 km and orbits the sun every 16500 hours at a distance of $2.28 \times 10^{8} km$. A day on Mars is 24 hours and 39 minutes long.

Question 12
Calculate the acceleration due to gravity at the surface of Mars.

_____

_____

2 marks

Question 13
Calculate the period of revolution of Mars about the Sun in seconds.

_____

1 mark

Question 14
Calculate the mass of the Sun.

_____

_____

_____

_____

_____

3 marks

Steve wishes to launch a geostationary satellite above the surface of Mars.

Question 15
Calculate the distance above the surface of Mars of the satellite.

_____

_____

_____

_____

_____

4 marks

SECTION A – AREA OF STUDY 1 – continued
TURN OVER

Question 16
Calculate the speed of Steve's geostationary satellite in km/ s.

_____

_____

2 marks

Roger is flying his jet aeroplane due South at a speed of 300 km/ hr and Justine is flying her aeroplane due West at a speed of 400 km/ hr.

Question 17
Calculate the velocity of Roger relative to Justine. Indicate the direction of the velocity as a true bearing from North.

_____

_____

_____

2 marks

A car drives around a roundabout at a constant speed of 20 km/ hr. The roundabout has a radius of 3.5 m and the car a mass of 1 200 kg.

Question 18
Calculate the speed of the car in m/ s.

_____

1 mark

Question 19
Calculate the magnitude and direction of the net force acting on the car.

_____

_____

2 marks

END OF AREA OF STUDY 1
SECTION A– continued

Area of Study 2- Electronics and Photonics

Figure 1 below shows the variation of the resistance of a thermistor with temperature.

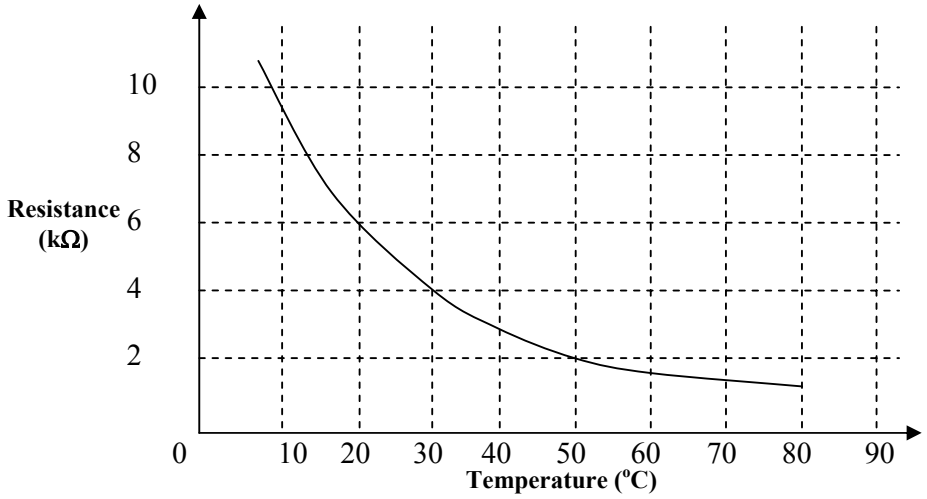


Figure 1

The thermistor is connected in series with 4 kΩ resistance and a 12 V DC power supply as shown in **Figure 2** below.

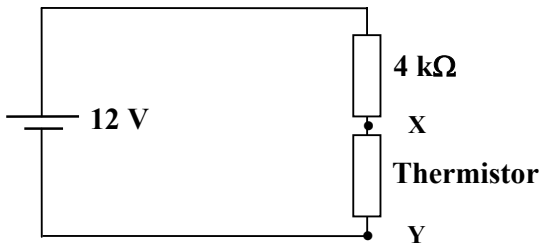


Figure 2

SECTION A – AREA OF STUDY 2 – continued
TURN OVER

The thermistor is placed in warm water at an initial temperature of 50° C and the voltage across XY is measured.

Question 1
Calculate the voltage across XY at 50° C.

_____

_____
2 marks

The water is now left to cool down to room temperature at 20° C.

Question 2
Calculate the voltage across XY at 20° C.

_____

_____
2 marks

Kate wishes to maintain the water temperature at 50° C by a heating element placed into the water.

Question 3
Should Kate connect the heating element across the 4 kΩ resistor or XY?
Justify your answer.

_____

_____
2 marks

Kate notices that the heating element maintains the water temperature at 40° C rather than 50° C. The resistance of the heating element can be easily altered by Kate.

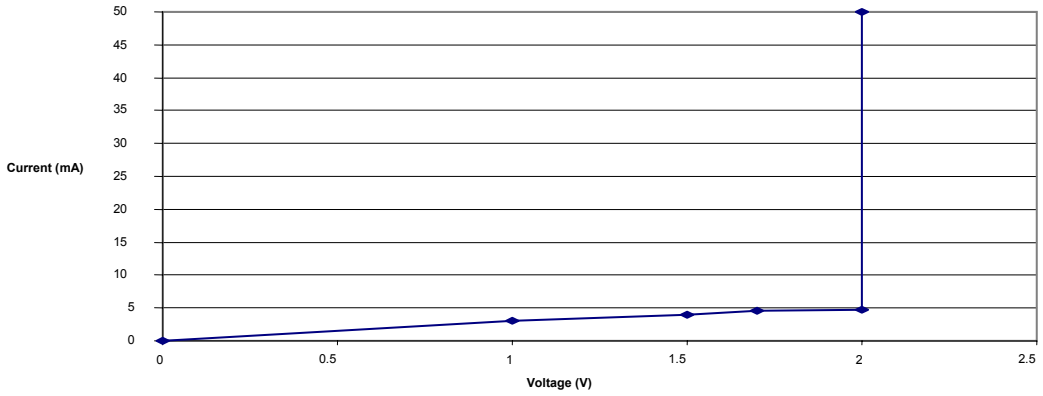
Question 4
What changes are necessary to the resistance of the heating element in order to maintain the water at 50° C? Justify your answer.

_____

_____
2 marks

A red LED with a maximum power rating of 300 mW has a characteristic curve given by **Figure 3** below:

Figure 3:



The LED is to be connected in series to a 6 V battery and a resistor.

Question 5

Calculate the minimum value of the resistor so that the LED does not exceed its maximum power rating.

_____

_____

3 marks

Question 6

Calculate the effective resistance of the LED when dissipating 300 mW of power.

_____

1 mark

LDRs, photodiodes and phototransistors are used in photonic circuits and respond to changes in light intensity. Janet wants to build a circuit to measure tiny changes of light intensity from a distance star she is observing through her telescope.

Question 7

Should Janet use a LDR, photodiode or phototransistor in the circuit she is to build? Justify your answer.

_____

_____

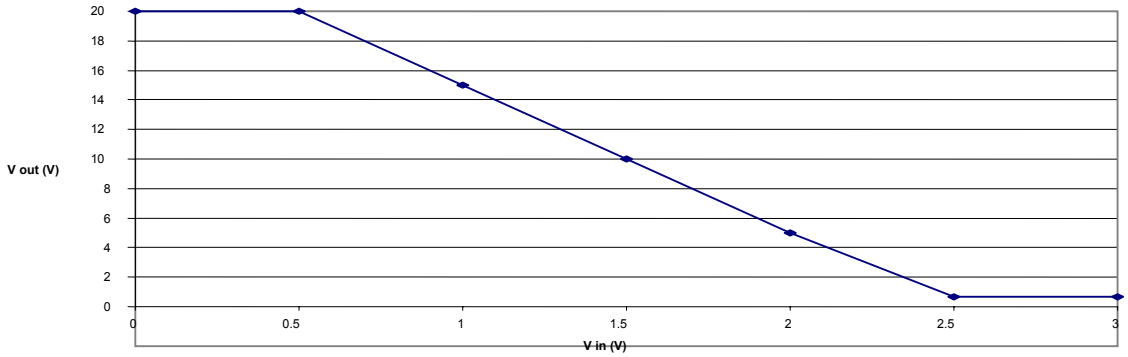
2 marks

SECTION A – AREA OF STUDY 2 – continued

TURN OVER

The characteristic curve for a transistor amplifier circuit is given in **Figure 4** below:

Figure 4:



Question 8
Estimate from the graph the magnitude of the gain for this amplifier.

_____

1 mark

Question 9
What is the supply voltage of this amplifier?

_____

1 mark

Question 10
State the co-ordinates of the optimum quiescent point for this amplifier.

_____

1 mark

A voltage divider is used to correctly bias the transistor amplifier. The value of the upper resistor in the divider is 500 kΩ. The voltage divider is connected in series with the supply voltage.

Question 11
Calculate the value of the lower resistor in order to correctly bias the transistor at the quiescent point.

_____

_____

_____

3 marks

SECTION A – AREA OF STUDY 2 –continued

Question 12
Explain how a capacitor can be used to decouple a combined DC and AC voltage signal.

_____

_____

_____

2 marks

Question 13
Which statement below is true?

A. The current through the photodiode and the output voltage will both increase.
B. The current through the photodiode and the output voltage will both decrease.
C. The current through the photodiode will increase but the output voltage will decrease.
D. The current through the photodiode will decrease but the output voltage will increase.

_____

2 marks

Question 14
Which one or more of the following statements is/are correct?

A. A LED is an opto-electric transducer.
B. A LED is an electric-opto transducer.
C. A photodiode is an opto-electric transducer.
D. A photodiode is an electric-opto transducer.

_____

1 mark

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.
Answer the multiple choice questions, in pencil, on the multiple choice answer page provided.
All questions in this section are worth 2 marks.
You should take the value of g to be $10 ms^{-2}$

Detailed Study 1 – Einstein's special relativity

Tom and Jerry board two spaceships on Earth. The spaceships leave the Earth and accelerate up to a top speed of $2.3\times10^8 m/s$ relative to the Earth. Tom's spaceship travels in an opposite direction to Jerry's spaceship.

Question 1
According to **Newton's Laws of Motion** the speed of Jerry relative to Tom is:

A. 0 m/ s
B. 2.3×10^8 m/ s
C. 4.6×10^8 m/ s
D. None of the above

Question 2
According to **Einstein's special relativity** the time and length dilation factor of Jerry's spacecraft as measured by an observer on planet Earth is:

A. 1.56
B. 0.64
C. 1
D. 2.42

Question 3
Under what circumstances do Newton's Laws of Motion give a more accurate calculation of relative velocity between two objects?

A. For speeds very much slower than that of light
B. For speeds approximately equal to that of light
C. For speeds in excess of that of light
D. Never

Donald has built a super fast space ship that can travel at 30% of the speed of light.
He sets out from Earth for the planet Pluto which is $5.9 \times 10^9 \, km$ away from the Earth. Daisy is on Earth and is observing Donald's journey. Daisy and Donald synchronise their watches so that both watches read 12:00 noon when Donald takes off.

Question 4
What time does Daisy's watch read at the instant Donald arrives at Pluto?

A. 6:12:36 am
B. 6:12:36 pm
C. 5:46:43 am
D. 5:46:43 pm

Question 5
What time does Donald's watch read at the instant Donald arrives at Pluto?

A. 3:55:17 am
B. 3:55:17 pm
C. 5:22:17 am
D. 5:22:17 pm

Donald's spacecraft is 7 m in length.

Question 6
Calculate the length of Donald's spacecraft as measured by Daisy.

A. 7.33 m
B. 6.68 m
C. 7 m
D. 0 m

Mickey is heading towards Earth after a voyage from outer space. Minnie is on Earth observing Mickey's journey. Mickey's spacecraft is 10 m long.
Minnie measures Mickey's spacecraft to be only 9 m long.

Question 7
The velocity of Mickey's spacecraft relative to Earth as a percentage of light speed is:

A. 27.6 %
B. 36.2 %
C. 43.6 %
D. 52.7 %

Mickey measures the time taken to return to Earth as 2 days 13 hours 4 minutes and 47 seconds.

Question 8
The time taken for Mickey's journey as measured by Minnie is closest to:

A. 2 days 15 hours and 52 minutes
B. 2 days 17 hours and 37 minutes
C. 2 days 19 hours and 48 minutes
D. 3 days 0 hours and 5 minutes

In particle accelerators protons are accelerated from rest using 11 GeV of energy. The rest mass of a proton is $1.67 \times 10^{-27} kg$.

Question 9
The increase in mass of the proton as it is accelerated is:

A. 0 kg
B. 1.34×10^{-26} kg
C. 1.75×10^{-26} kg
D. 1.96×10^{-26} kg

Question 10
How many times increase in mass does the proton acquire over its rest mass?

A. 0
B. 8.0
C. 10.5
D. 11.7

Question 11

The Michelson-Morley experiment was designed to:

A. Measure the speed the Earth moves through the aether
B. Accurately measure the speed of light
C. Test Einstein's theory of relativity
D. Show it is impossible to travel faster than light

Question 12

An inertial frame is a frame of reference that is:

A. Not moving
B. Not moving or moving at constant velocity
C. Not moving or moving at constant velocity or moving at constant acceleration
D. unable to be measured accurately

Question 13

When an object is accelerated its:

A. Mass increases and length increases
B. Mass increases and length decreases
C. Mass decreases and length increases
D. Mass decreases and length decreases

END OF DETAILED STUDY 1
TURN OVER

Detailed Study 2 – Investigating materials and their use in structures

Lucy is an Engineer and has been asked to design a steel cable for a crane to support a 10 tonne load. The cable is 20 m in length and is to be designed with a safety factor of 4. The steel Lucy is to use has a Young's modulus of 210 GPa and an ultimate tensile strength of 400 MPa.

Question 1
The maximum allowable stress in the cable is:

A. 50 MPa
B. 100 MPa
C. 400 MPa
D. 1600 MPa

Question 2
The minimum cross sectional area of the steel cable in mm^2 is:

A. 100 mm^2
B. 500 mm^2
C. 1000 mm^2
D. 5000 mm^2

Question 3
The minimum diameter of the cable in mm is:

A. 17.8 mm
B. 35.7 mm
C. 16.2 mm
D. 32.4 mm

Question 4
The strain in the cable at the maximum allowable stress is:

A. 2.28×10^{-2}
B. 2.28×10^{-4}
C. 4.76×10^{-2}
D. 4.76×10^{-4}

Question 5
The elongation of the cable at the maximum allowable stress is:

A. 4.6 mm
B. 40.6 mm
C. 9.5 mm
D. 90.5 mm

Question 6
The strain energy per m^3 stored in the cable at the maximum allowable stress is:

A. 2.38×10^{4} J/ m^3
B. 4.76×10^{4} J/ m^3
C. 7.14×10^{4} J/ m^3
D. 9.52×10^{4} J/ m^3

Question 7
The volume of material in the cable is:

A. 1×10^{-2} 1 m^3
B. 2×10^{-2} 2 m^3
C. 3×10^{-2} 3 m^3
D. 4×10^{-2} m^3

Question 8
The strain energy in the cable at the maximum allowable stress is:

A. 176 J
B. 276 J
C. 376 J
D. 476 J

Tom has a choice of two building materials for a bridge. He can choose between mild steel and cast iron.

Question 9
The material Tom should choose is:

A. Mild steel because it is ductile
B. Mild steel because it is brittle
C. Cast Iron because it is ductile
D. Cast Iron because it is brittle

Tina has two materials.
Material A is strong in tension but weak in compression.
Material B is strong in compression but weaker in tension.

Question 10
Which of the following is a possibility for Material A?

A. Concrete but not paper
B. Paper but not concrete
C. **Either** concrete or paper
D. Neither paper nor concrete

Question 11
Which of the following is a possibility for Material B?

A. Concrete but not paper
B. Paper but not concrete
C. Concrete or paper
D. Neither paper nor concrete

Concrete has an ultimate compressive strength of 20 MPa. George is designing a square concrete column to support a 15 tonne load. The column is to be designed with a safety factor of 4.

Question 12
The minimum side length of the square column to support the load is:

A. 73 mm
B. 173 mm
C. 273 mm
D. 373 mm

Engineers often put steel reinforcement in concrete beams.

Question 13
Steel reinforcement is:

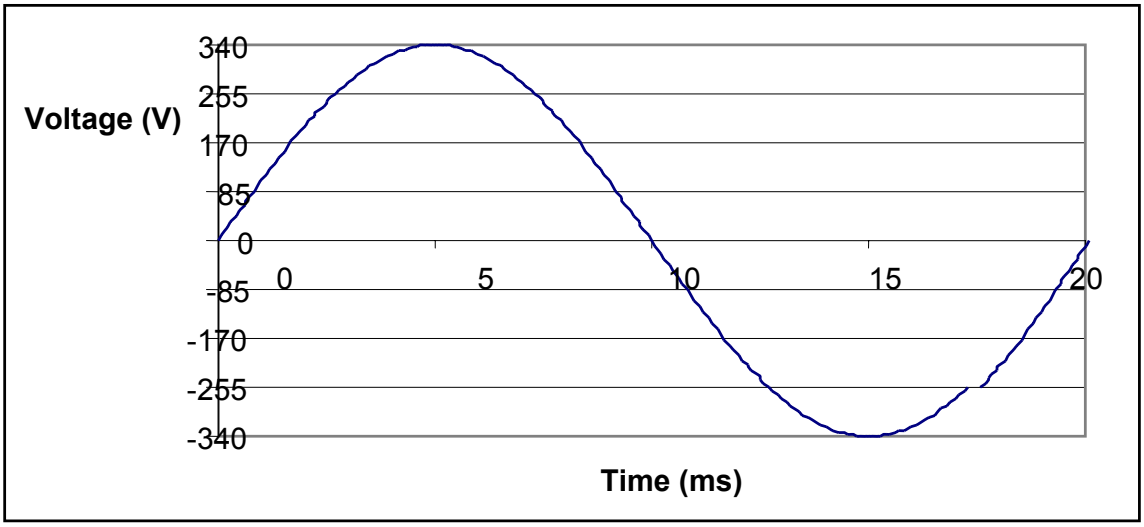
A. Placed in the top of beams to take tensile stresses
B. Placed in the top of beams to take compressive stresses
C. Placed in the bottom of beams to take tensile stresses
D. Placed in the bottom of beams to take compressive stresses

END OF DETAILED STUDY 2

Detailed Study 3 – Further Electronics

The trace in figure 1 was produced on a CRO when connected across an electronic device running on the AC supply voltage. At time t = 5 ms the current through the electronic device was 35 mA.

Figure 1 :



Question 1
From the trace indicated in **Figure 1** the peak to peak voltage is:

A. 240 V
B. 340 V
C. 680 V
D. 20 V

Question 2
From the trace indicated in **Figure 1** the RMS voltage is:

A. 240 V
B. 340 V
C. 680 V
D. 20 V

Question 3
From the trace indicated in **Figure 1** the frequency of the supply is:

A. 20 Hz
B. 50 Hz
C. 240 Hz
D. 680 Hz

SECTION B – Detailed Study 3 – continued
TURN OVER

Question 4
The average power consumed by the electronic device is:

A. 2.95 W
B. 3.95 W
C. 4.95 W
D. 5.95 W

The following information applies to Questions 5 to 7.

Terry owns a small radio that runs on DC batteries. He wishes to build an electronic circuit to enable him to run the radio from mains supply. The mains supply is providing 240 V RMS AC.
Terry has the following components at his disposal: 4 diodes, a transformer and a capacitor.
The turns ratio of the transformer is $N_P : N_S = 20 : 1$

Question 5
The value of the AC voltage after it is transformed is:

A. 6 V
B. 12 V
C. 18 V
D. 24 V

Question 6
The order in which Terry should connect the components in his circuit is:

A. Diodes, Transformer, Capacitor
B. Capacitor, Transformer, Diodes
C. Transformer, Diodes, Capacitor
D. Diodes, Capacitor, Transformer

Question 7
The purpose of the capacitor in the circuit is to:

A. Reduce the size of the RMS voltage
B. Rectify the signal
C. Smooth the signal
D. Prevent the user from electric shock

The diodes in Terry's circuit have a switch on voltage of 0.7 V.

Question 8
The output voltage to the radio is:

A. 12.7 V
B. 12.0 V
C. 10.6 V
D. 9.2 V

The following information applies to Questions 9 to 11

A 4.5 V Zener diode is connected in series with a 10 kΩ resistor and a power supply which has a voltage ripple which varies from 5 to 7 V. Amy wishes to use the circuit to power an IC chip for a computer which requires a constant voltage of 4.5 V.

Question 9
Amy should connect the IC chip for the computer:

A. In series with the Zener diode
B. In parallel with the Zener diode
C. In series with the 10 kΩ resistor
D. In parallel with the 10 kΩ resistor

Question 10
After running the circuit for a period of time Amy notices that the circuit gets warm. This is occurring because:

A. The 10 kΩ resistor dissipates the voltage above 4.5 V as heat
B. The Zener diode dissipates the voltage above 4.5 V as heat
C. The 10 kΩ resistor dissipates the voltage below 4.5 V as heat
D. The Zener diode dissipates the voltage below 4.5 V as heat

Question 11
The power dissipated in the 10 kΩ resistor is:

A. 1.25×10^{-4} W
B. 2.25×10^{-4} W
C. 3.25×10^{-4} W
D. 4.25×10^{-4} W

Julian suggests to Amy that she could use a 7805 IC voltage regulator rather than a Zener diode and 10 kΩ resistor.

Question 12
A 7805 IC voltage regulator does not require a 10 kΩ resistor because:

A. The excess voltage is dissipated as heat within the 7805 IC voltage regulator
B. The resistance of the 7805 IC voltage regulator is sufficient
C. Too little current would flow through the 7805 IC voltage regulator if it had a 10 kΩ resistor connected
D. All of the above

A full wave rectifier has an output with a peak value of 12 V and a frequency of a 50 Hz. It is connected to a 20 kΩ load resistor and a 100 μF smoothing capacitor.

Question 13
The peak to peak ripple voltage in the 20 kΩ resistor is closest to:

A. 0.06 V
B. 0.12 V
C. 0.18 V
D. 0.24 V

END OF QUESTION AND ANSWER BOOK

