Centre Number

Student Number

2012
HSC PRE-TRIAL EXAMINATION

Physics

General Instructions

- Reading time – 5 minutes
- Working time – 2 hours
- Write using black or blue pen
- Draw diagrams using pencil
- Board-approved calculators may be used
- Use the Data Sheet and Periodic Table provided at the back of the paper.
- Use the Multiple-Choice Answer Sheet provided at the back of the paper
- Write your Centre Number and Student Number at the top of this page, page 11 and on the Multiple-Choice Answer Sheet

Total marks – 70

Section I Pages 4-21

70 marks
This section has two parts, Part A and Part B

Part A – 13 marks
- Attempt Questions 1-13
- Allow about 22 minutes for this part

Part B – 57 marks
- Attempt Questions 14-24
- Allow about 98 minutes for this part

Questions 1 & 2 Refer to the following situation.

Daniel and John are playing paintball. Daniel fires a 'paintball' at an angle of 25° to the horizontal and a speed of 40.0 m s^{-1}. The paintball hits John, who is 127m away. The height at which the ball hits John and the height from which the ball was fired are the same. The situation is shown.

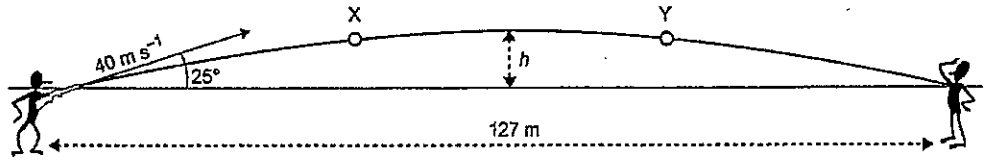


Figure 4

Question 1 ST

What is the time of flight of the paintball?

A. 1.7s

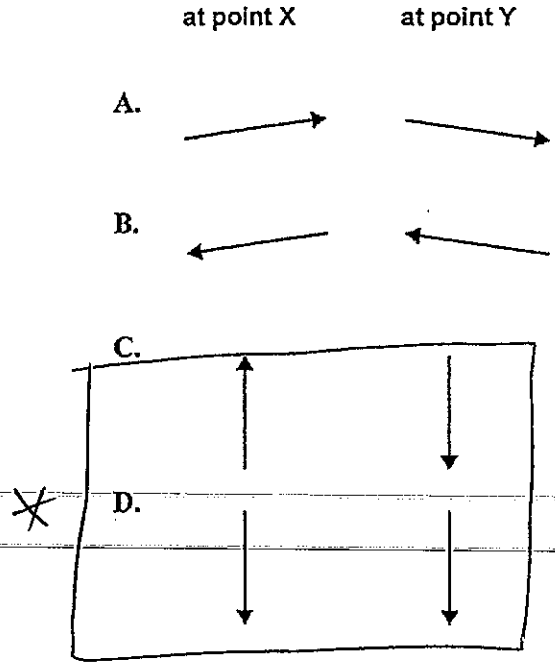
B. 2.1s

C. 2.7s

✳ D. 3.4s

Question 2 K&U

Which of the following diagrams (**A–D**) below gives the direction of the force acting on the paintball at points X and Y respectively?



Question 3 K&U

In order to minimize the fuel required to place a satellite into Low Earth Orbit it should be launched towards the:

A. North

B. East

C. South

D. West

Question 4 K&U

Jupiter has an orbit around the sun of 778,000,000 kms compared to the Earth's 150,000,000 km. What is the orbital period of Jupiter in Earth years?

A. 18.2

B. 3.6

C. 11.9

D. 0.8

Question 5 ST

The radius of the moon is approximately 1,738 km. A 400kg is moved from an initial orbit of 869km above the surface of the moon to an orbit that is 2607 km above the surface of the moon. In doing so the burning of fuel resulted in a mass reduction of 200kg for the satellite.
What is the magnitude of the gravitational attraction between the moon and satellite in the final orbit compared to the initial orbit.

A. One eighth as much

B. One quarter as much

C. The same

D. Twice as much

Question 6 K&U

Indicate the correct relationship between Geosynchronous and Low Earth Orbit satellites of equal mass.

	Geosynchronous	**Low Earth Orbit**
A	Shorter Period	Longer Period
B	Higher Orbital Speed	Lower Orbital Speed
C	Higher Potential Energy	Lower Potential Energy
D	Higher Kinetic Energy	Lower Kinetic Energy

Question 7 K&U

Ann and Bill are travelling in space in identical spaceships as shown in Figure 1 below. Ann knows that each spaceship is of proper length L_0. At some time Ann observes Bill's ship passing her with a speed v, and she measures its length.

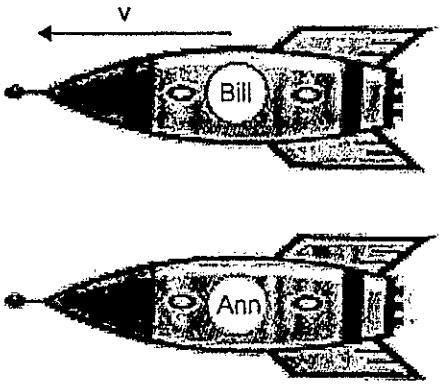


Figure 1

Which of the following **(A–D)** best represents the length (L) of Bill's ship as measured by Ann?

A. $L = \dfrac{L_0}{\sqrt{1 - v^2/c^2}}$

B. $L = L_0\sqrt{1 - v^2/c^2}$

C. $L = \dfrac{L_0}{\sqrt{1 + v^2/c^2}}$

D. $L = L_0\sqrt{1 + v^2/c^2}$

Question 8

In which mission is the slingshot effect most likely to be employed?

A. A manned space flight to the moon.

B. An unmanned space-probe to Uranus.

C. The launch of a geostationary communication satellite.

D. The positioning of a Low Earth Orbit Satellite

Question 9

Which of the following is an unlikely consequence of a manned capsule re-entering the Earth's atmosphere at too steep an angle?

A. 'Skipping' back into space.

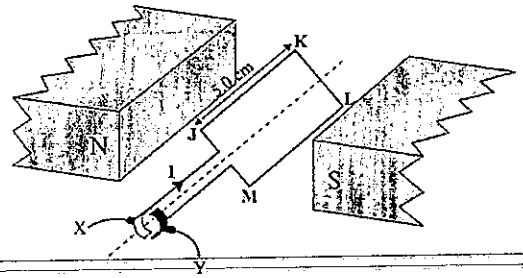
B. Structural damage of the craft due to high 'g' forces.

C. Injury to the occupants due to high 'g' forces

D. Heat damage to craft due to excess air resistance.

Question 10

In the schematic diagram of an electric motor shown below identify the structure that the leads **X** and **Y** are connected to.



A. Stator

B. Coil

C. Commutator

D. Brushes

Question 11

Two parallel wires that are 5mm apart have currents of 2A flowing in them in opposite directions. What is the force per unit length between them?

A. 1.6×10^{-4} Nm^{-1} Repulsion

B. 1.6×10^{-4} Nm^{-1} Attraction

C. 1.6×10^{-7} Nm^{-1} Attraction

D. 1.6×10^{-7} Nm^{-1} Repulsion

Question 12

The primary purpose of having a laminated Iron core in a step-up transformer is to:

A. to increase flux density and flux linkage between the coils

B. to reduce eddy currents in the transformer

C. to increase the output voltage

D. to reduce back emf as a consequence of Lenz's Law

Question 13

An electric motor is connected to a source of emf that is capable of a constant supply voltage of 12V. Immediately on start up it draws a current 10A.

After the motor has reached a constant angular velocity the current drawn is 1A. What is the back emf in this situation?

A. 12 V

B. 10.8 V

C. 2.4 V

D. 1.2V

Part B – 67 marks
Attempt Questions 14-24

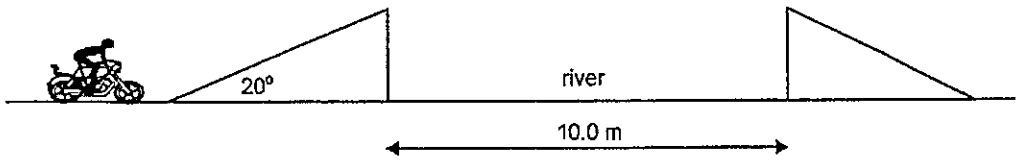
Allow about 98 minutes for this part

Answer the questions in the spaces provided.

Show all relevant working in questions involving calculations.

Question 14 **4 Marks**

The diagram below shows a motorcycle rider using a 20° ramp to jump the motorcycle across a river that is 10.0 m wide.



The rider plans on the motorcycle leaving the first ramp at 54kph. Is this a sufficient speed to ensure that the motorcycle and rider reach the second ramp? Justify your answer.

$V_0 = \frac{54}{3.6} = 15\ ms^{-1}$ $u_x = 15\cos 20 = 14.1\ ms^{-1}$

$u_y = 15\sin 20 = 5.1\ ms^{-1}$

$t = \frac{2u_y}{a_y} = \frac{10.2}{9.8} = 1.05$ secs

$R = u_x t = 14.1 \times 1.05$

$= 14.8\ m$

Will clear jump $14.8 > 10$

Question 15

A spacecraft of mass 400 kg is placed in a circular orbit of period 2.0 hours about Earth. The radius of the Earth is approximately 6,400km.

Part i **3 Marks**

Show that the spacecraft orbits at a height of 1.70×10^6 m above the surface of Earth.

Mass irrelevant (satellite)

Use $\frac{R^3}{T^2} = \frac{GM}{4\pi^2}$ $R = \sqrt[3]{\frac{GMT^2}{4\pi^2}}$

$G = 6.7 \times 10^{-11}$ $M_e = 6 \times 10^{24}$ Kg $T = 2 \times 60 \times 60 = 7,200$

$R = \sqrt[3]{\frac{6.7 \times 10^{-11} \times 6 \times 10^{24} \times 7,200^2}{4\pi^2}}$

$= 1.7 \times 10^6$ m.

Part ii **2 Marks**

Calculate the speed of the spacecraft in this orbit of period 2.0 hours.

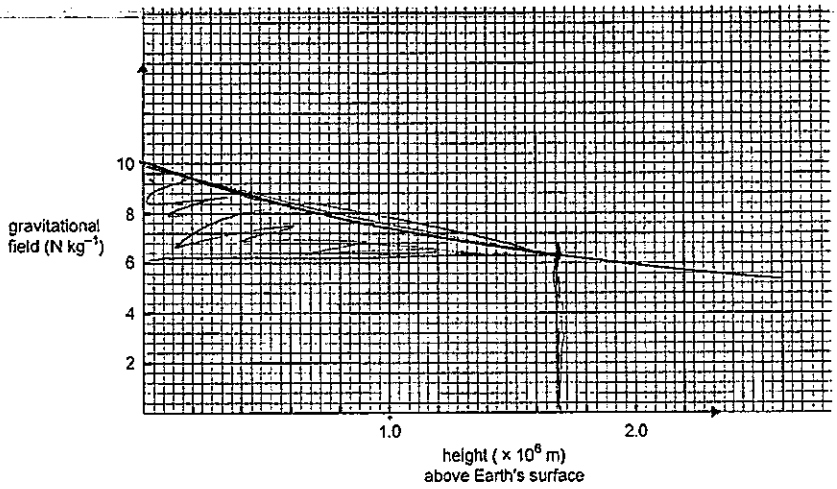
$v = \frac{2\pi r}{T}$

$= \frac{2 \times \pi \times 1.7 \times 10^6}{7.2 \times 10^3}$

$= 1.5 \times 10^3$ ms^{-1}

Part iii

The diagram below shows the variation of gravitational field with height above Earth's surface.



3 Marks

Calculate the energy needed to take the 400 kg spacecraft from rest at the surface of Earth and place it in a stable circular orbit of height 1.70×10^6 m. You must show your working.

ENERGY NEEDED = WORK = FORCE × DISTANCE

= G × GRAVITATIONAL FIELD × MASS × DISTANCE

= SHADED AREA × 400

= $\frac{1}{2}$ B × H × 400

= $\frac{1}{2} \times 1.7 \times 10^6 \times 4 \times 400$

= 1.4×10^9 J

Question 16 **2 Marks**

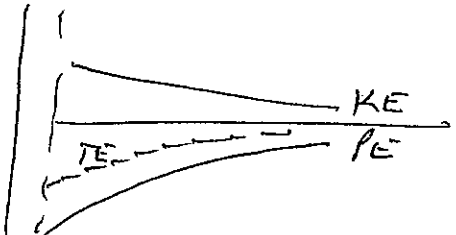
Account for the orbital decay of satellites in low earth orbit.

UPPER ATMOSPHERE APPLIES OPPOSING FORCE

THEREFORE REMOVES ENERGY FROM SATELLITE

~~LOSS OF~~ ∴ TOTAL ENERGY DECREASES AS RADIUS

OF ORBIT DECREASES ∴ ORBIT OF SATELLITE DECREASE



Question 17 **3 Marks**

Explain qualitatively the consequence of special relativity in relation to simultaneity.

BECAUSE THE SPEED OF LIGHT IS MEASURED AS CONSTANT NO MATTER WHAT FRAME OF REFERENCE IT IS OBVERSED TWO EVENTS THAT ARE OBSERVED TO BE SIMULTANEOUS FROM ONE FRAME MAY NOT BE OBSERVED TO BE SIMULTANEOUS WHEN MEASURED FROM A SECOND FRAME THAT IS MOVING WITH RESPECT TO THE FIRST.

Question 18 **2 Marks**

A muon is a subatomic particle with a mean lifetime of 2.2×10^{-6}s. If muons were to be accelerated to 0.8c in a linear accelerator what would a scientist in the laboratory measure their mean lifetime to be?

$$t_v = \frac{t_0}{\sqrt{1-\frac{v^2}{c^2}}} = \frac{2.2\times10^{-6}}{\sqrt{1-\frac{0.8^2c^2}{c^2}}} = \frac{2.2\times10^{-6}}{0.6}$$

$$t_v = 3.7\times10^{-6}\ \text{s}.$$

Question 19 **6 Marks**

Discuss the implications of mass increase, time dilation and length contraction for space travel.

MASS INCREASE

DUE THE EQUATION $M_V = \frac{M_0}{\sqrt{1-\frac{v^2}{c^2}}}$ AS

A SPACECRAFT APPROACHES THE SPEED OF LIGHT ITS MASS WILL INCREASE AND THEREFORE IT WILL REQUIRE MORE ENERGY FOR ANY GIVEN INCREASE IN VELOCITY

TIME DILATION & LENGTH CONTRACTION.

FROM A STATIONARY OBSERVER THE TIME IN THE SPACE CRAFT WILL DILATE ACCORDING TO AN OBSERVER ON EARTH. $t_V = \frac{t_0}{\sqrt{1-\frac{v^2}{c^2}}}$

FROM THE SPACECRAFT THE DISTANCE ~~TO~~ FOR THE JOURNEY WILL CONTRACT $l_0 = l_0\sqrt{1-\frac{v^2}{c^2}}$

THEREFORE TIME FOR THE JOURNEY WILL BE LESS AS MEASURED IN THE SPACE CRAFT COMPARED TO EARTH.

Question 20

A simple generator has been constructed as shown **(Figure 1)**.

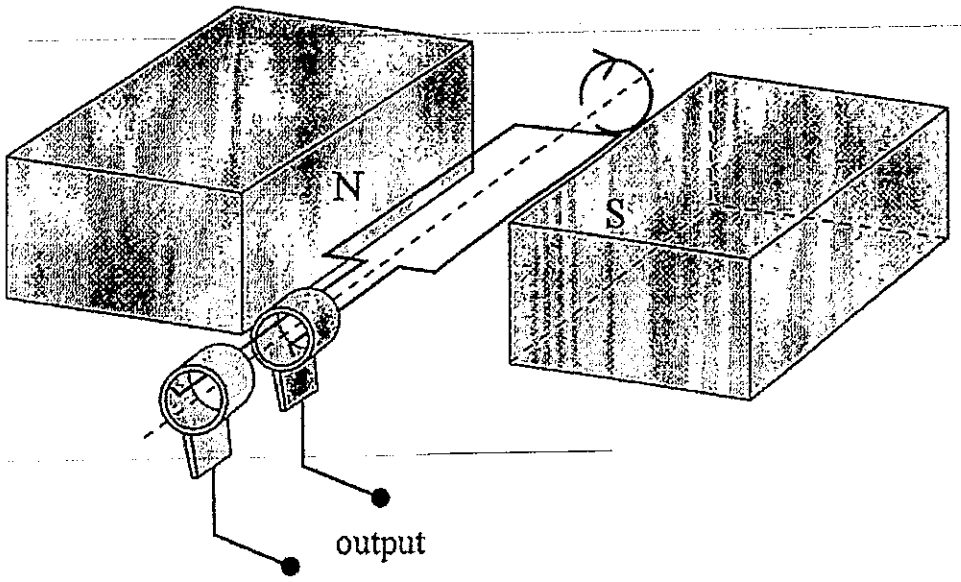


Figure 1

Part i **2 Marks**

Indicate, with an explanation, whether this device is a DC generator or an AC generator (alternator).

THIS IS AN AC GENERATOR AS IT HAS SLIP RINGS. THE DIRECTION OF CURRENT IN THE EXTERNAL CIRCUIT WILL REVERSE EVERY HALF TURN AS THE DIRECTION OF THE CONDUCTOR THROUGH THE FIELD REVERSES.

Part ii **2 Marks**

The coil is a single rectangular loop of effective area 9.0×10^{-4} m^2.
The coil can be rotated about an axis as shown, in a uniform magnetic field, **B**, larger in area than the coil. The maximum magnetic flux that passes through the coil is 7.2×10^{-6} Wb. What is the magnitude of the uniform magnetic field?

$\Phi = BA$ $\quad B = \Phi / A$

$B = \dfrac{7.2 \times 10^{-6}}{9.0 \times 10^{-4}}$

$= 8 \times 10^{-1}$ T

Part iii **2 Marks**

In an interval of 0.020 s the coil is rotated by one quarter turn (90°) from the orientation shown in Figure 1.

What is the magnitude of the **maximum** emf generated?

$EMF = -n\frac{d\phi}{dt}$ $d\phi = 7.2\times10^{-6}$

$dt = 0.02$ $n = 1$

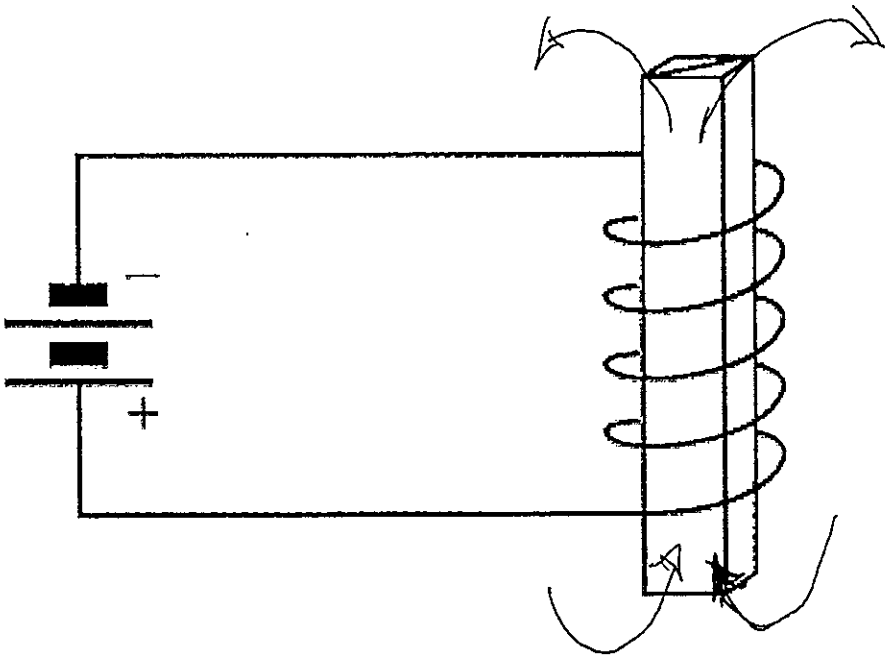
$EMF = \frac{7.2\times10^{-6}}{0.2}$

$= 3.6\times10^{-5}$ V.

Question 21

Part I **2 Marks**

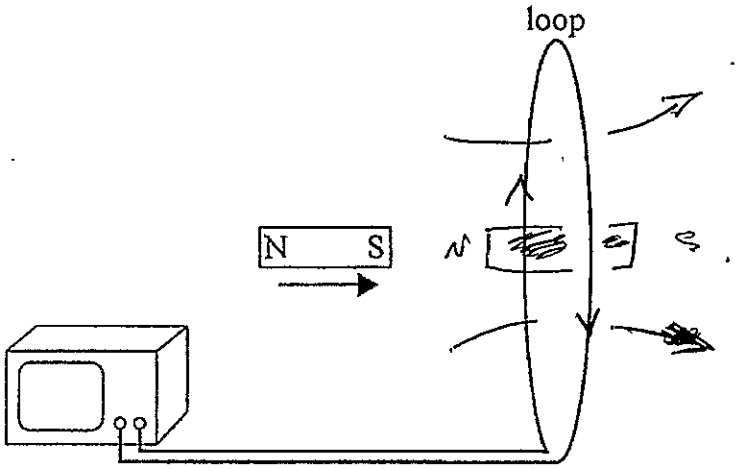
A coil of wire is placed around an iron bar. The coil is connected to a DC battery. This is shown below.



On the diagram draw **four** lines, each with an arrow indicating direction, that show the magnetic field in the region around the iron bar.

Part ii **4 Marks**

A small bar magnet is moved through a circular wire loop, as shown in Figure 5. The magnet moves with **constant** speed through the centre of the loop, in the direction shown by the arrow. An emf is generated in the wire loop. The wire loop is connected to an oscilloscope, as shown. Regard the part of the loop on the right of the diagram to be closest to the observer.

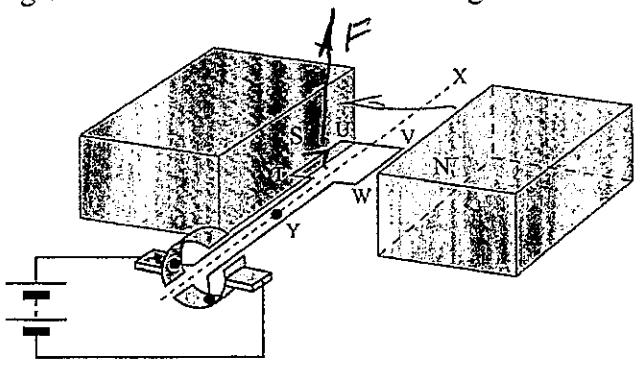


Indicate the direction of the magnetic field through the loop and explain why an emf is generated in the wire loop and

THE FIELD WILL PASS THROUGH THE LOOP FROM LEFT TO RIGHT. THE CHANGING MAGNETIC FIELD EXPERIENCED BY THE LOOP WILL INDUCE AN EMF WHICH WILL GIVE RISE TO A CURRENT. ~~THIS CURRENT~~ (FARADAY'S LAW $\mathcal{E}_{ind} = -n\frac{d\Phi}{dt}$) THIS CURRENT WILL PRODUCE A MAGNETIC FIELD WHICH WILL OPPOSE THE MOVEMENT OF THE MAGNET. : LEFT SIDE 'SOUTH' DUE TO LENZ'S LAW.

Question 22

Figure 3 below shows a diagram of a simple DC motor. The single square loop coil **TUVW**, of side 0.0090 m, is free to rotate about the axis XY. Current is supplied from a battery via the split-ring commutator. The two permanent magnets provide a uniform magnetic field **B** of magnitude 0.25 T in the region of the coil. The current flowing in the coil is 2.0 amps.



FORCE ON TU ⇒ UP

Figure 3

Part i **1 Mark**

On the diagram, indicate with an arrow the direction of the force on side **TU** of the coil in Figure 3.

Part ii **2 Marks**

Calculate the magnitude of the force on the side **TU** of the coil. Show your working.

$F = BIL\sin\theta \quad \theta = 0 \quad B = 0.25\,T \quad I = 2\,A \quad L = 9\times10^{-3}\,m$.

$F = 0.25 \times 2 \times 9\times10^{-3}$

$= 4.5\times10^{-3}\,N$.

0.55.

Part iii **3 Marks**

What is the magnitude of the force acting on side **UV** of the coil when in the position shown in Figure 3? Justify your answer.

MAGNITUDE IS ZERO AS UV IS PARALLEL TO THE FIELD LINES SO $\sin\theta = 0$

$\therefore BIL\sin\theta = 0 \therefore F = 0$

Part iv **3 Marks**

Explain the purpose of the split-ring commutator.

A SPLIT RING COMMOTATOR REVERSES THE INPUT CURRENT EVERY HALF-TURN TO MAINTAIN THE DIRECTION OF TORQUE

Question 23

A diesel-powered portable DC generator is used to power lights on a light tower at an isolated football ground. The generator produces a constant 500 V DC and when the lights are on the current output at the generator is measured to be 20A. The generator is approximately 500 m from the light tower, and a two wire transmission line connects the generator to the lights. **Each** of the wires in the transmission lines has a resistance of 5.00 Ω. Ignore the resistance of the other connecting wires. The system is shown in Figure 4.

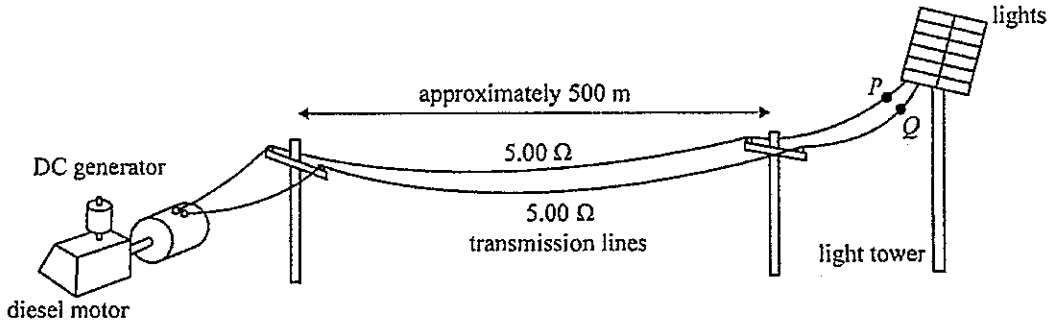


Figure 4

Part i **2 Marks**

What is the power output of the generator?

$P = VI$ $V = 500$ $I = 20A$

$P = 1 \times 10^4$ W.

Part ii **2 Marks**

Given that power loss in transmission lines can be determined using the equation $\mathbf{P = I^2R}$ what is the **total** power loss in the transmission lines?

$P = I^2R$

$= 20^2 \times 2 \times 5$

$= 400 \times 10$

$= 4 \times 10^3$ W.

The players find the lights too dim. They call in an electrical engineer who suggests the following:

- retain the diesel motor
- replace the DC generator with an AC alternator producing 500 V
- insert a 1:10 step-up transformer between the alternator and the power lines, and a 10:1 step-down transformer between the power lines and the light tower

The transformers can be considered ideal. The arrangement is shown in Figure 5.

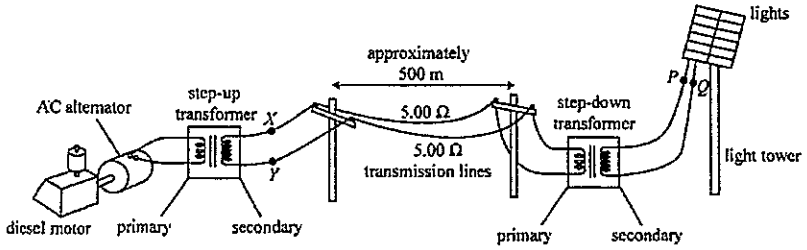


Figure 5

Part iii **4 Marks**

Explain the logic of setting up the circuit as indicated?

AC Alternating current can be transformed for transmission power transmitted = VI power loss = I^2R by increasing voltage current can be decrease for same amount of power and therefor less power loss. transformers can increase voltage at source decrease voltage at point of use enabling less power l

Part iv **2 Marks**

The primary of the step-up transformer has 220 turns. How many turns are in the secondary winding?

$\frac{n_p}{n_s} = \frac{V_p}{V_s}$ $\therefore n_s = \frac{n_p V_s}{V_p}$

$= 220 \times \frac{10}{1}$ $= 2200$ TURNS.

Part v **1 Mark**

What will be the voltage at the output of the step-up transformer?

$V_s = \frac{V_p n_s}{n_p} = \frac{500 \times 2200}{220} = 5000\,V$

Question 24 **2 Marks**

An AC alternator is rotating at a steady 50 revolutions per second. The output voltage, as measured on an oscilloscope, is shown below in Figure 6.
The rate of rotation of the alternator is now reduced to 25 revolutions per second.

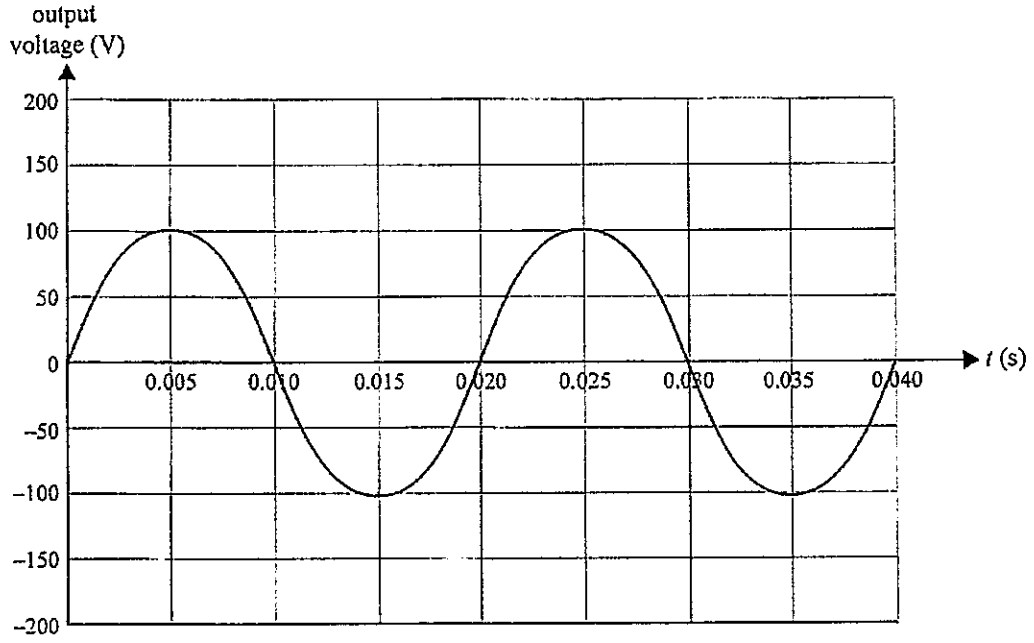
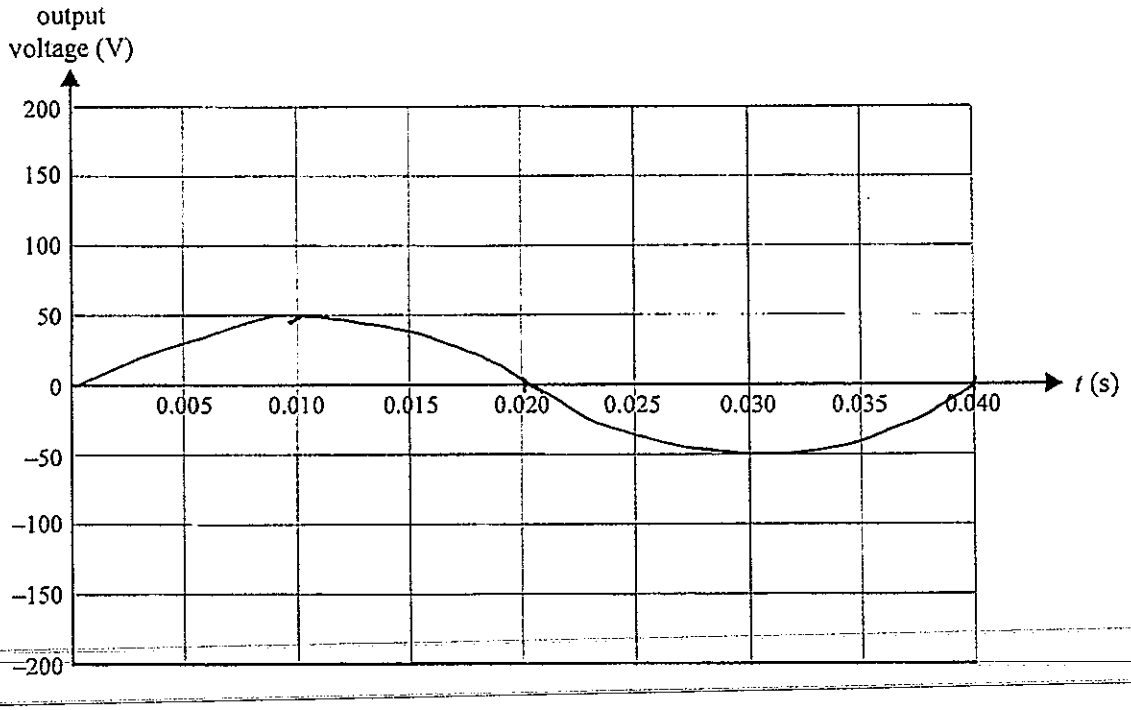


Figure 6

On the axes provided below, sketch how the output will now appear.



End Of Exam