# HILTON COLLEGE EXAMINATION
## AUGUST 2015
## GRADE 12
## PHYSICAL SCIENCES PAPER 1
## PHYSICS

**Time: 3 hours** **Marks: 200**

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EXAMINER: Mr. T. van Niekerk

MODERATOR: Mr. N. Robert

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## PLEASE READ THE FOLLOWING INSTRUCTIONS CAREFULLY

1. This paper consists of 17 pages. **This includes a page of formulae and data (pages 15 and 16). An answer sheet consisting of graph paper can be found on page 17.**
2. Please check that your question paper is complete.
3. **Write your Laundry Number on the answer sheet (page 17). Detach the answer sheet and insert it into your answer booklet when handing in your script.**
4. Read the questions carefully.
5. It is in your interest to write legibly and present your work neatly.

QUESTION 4 : MULTIPLE CHOICE

There is only one correct answer to each of the Multiple Choice questions. Mark the letter corresponding to the answer you think is correct with a cross as illustrated below.

| | | | | |
|---|---|---|---|---|
| A | B | ☒ C | D | Here “C” has been marked as the correct answer |

## SECTION B:

1. All questions in this section must be answered in your answer book.
2. Number your answers exactly as the questions are numbered.
3. All working must be shown and units given with your answers. Work to two decimal places.
4. Units need not be used in calculations. They MUST however be shown in the answers.

**QUESTION 1** *Multiple Choice Questions – Answer these questions on the front inside flap of your green answer booklet.*

1.1 The group that contains TWO vector quantities and ONE scalar quantity is

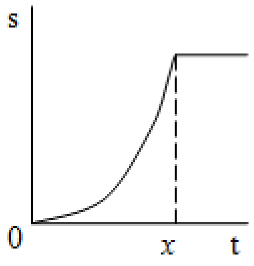
A energy, impulse, speed

B energy, speed, displacement

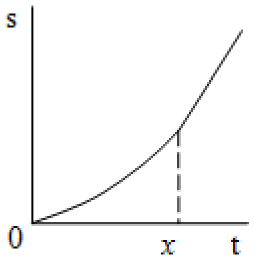
C distance, acceleration, electric field strength

D electric field strength, acceleration, velocity

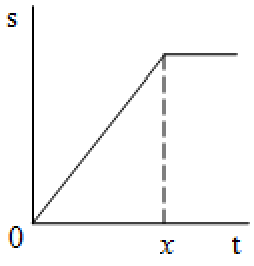
1.2 A body accelerates uniformly from rest for *x* seconds after which it continues with a constant velocity. Which graph is the CORRECT representation of the body's motion?



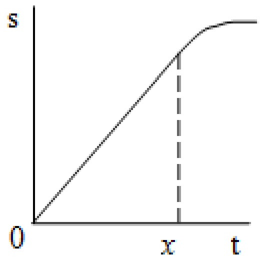
A



B



C



D

1.3 The physical quantity represented by the expression $\frac{m(v^2 - u^2)}{2s}$ is equivalent to

A resultant force

B momentum

C energy

D change in momentum

1.4 A workman, standing on a scaffold, lowers an object of weight 300 N at constant speed by means of a rope. The rope has negligible mass. The force the man exerts is

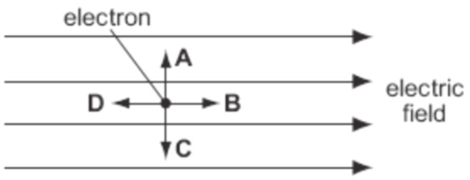
A equal to 300 N.

B constant and less than 300 N

C greater than 300 N

D less than 300 N and decreasing

1.5 The diagram below shows an electron in a uniform electric field. In what direction will the field accelerate the electron?



1.6 What is an equivalent unit to 1 volt?

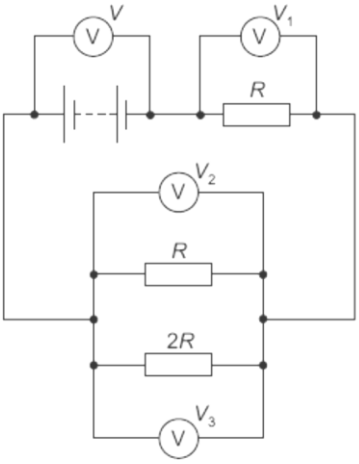
A $1\ J.A^{-1}$

B $1\ J.C^{-1}$

C $1\ W.C^{-1}$

D $1\ W.s^{-1}$

1.7 The diagram below shows a circuit with four voltmeter readings V, $V_1$, $V_2$ and $V_3$.



Which equation relating the voltmeter readings must be **true**?

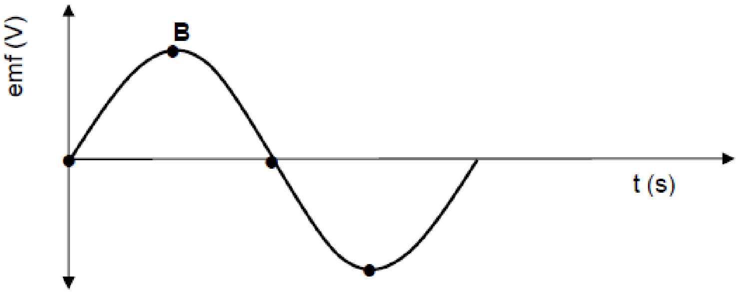
A $V = V_1 + V_2 + V_3$

B $V + V_1 = V_2 + V_3$

C $V_3 = 2(V_2)$

D $V - V_1 = V_3$

1.8 The coils of an AC generator make one complete rotation. The resulting graph for the output emf is shown below.



The position **B** on the graph is obtained when the plane of the coil is at an angle of … to the magnetic field.

A 120˚

B 90˚

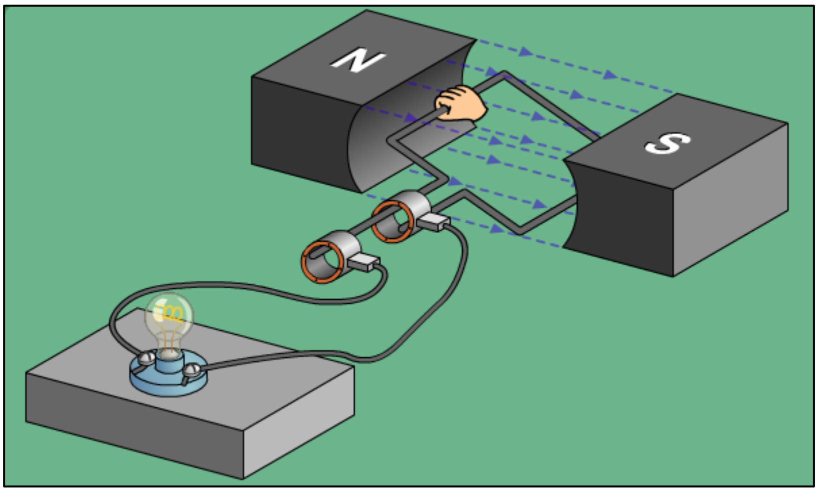
C 60˚

D 0˚

1.9 The speed of rotation of the coils in an AC generator is increased. Which ONE of the following combinations of frequency and output voltage for the generator will occur as a result of the change?

| | FREQUENCY | OUTPUT VOLTAGE |
|---|---|---|
| A | Increases | Increases |
| B | No change | Increases |
| C | Decreases | Decreases |
| D | Increases | No change |

1.10 What type of electrical machine is represented in the diagram below?



A a.c. motor

B d.c. motor

C a.c. generator

D d.c. generator

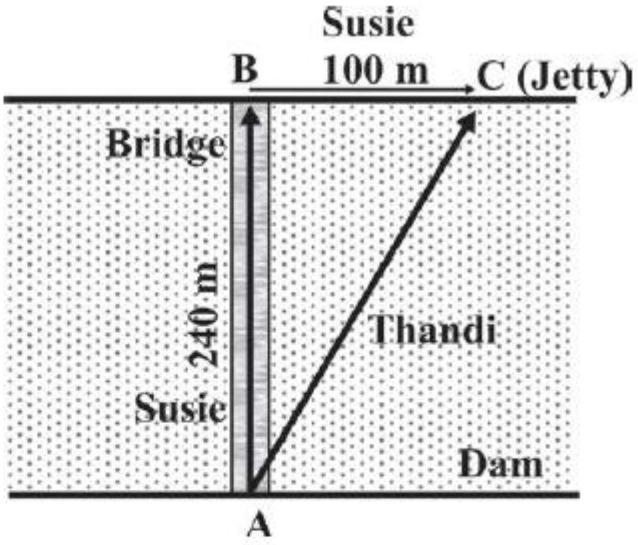
**[2 x 10 = 20]**

**SECTION B** *Remember to show all working for calculations, starting from given equations where possible.*

**QUESTION 2** – start at the top of a new page

Thandi drives a motor boat in still water across a dam directly from point A to a jetty at point C, as shown in the diagram below. Susie walks 240 m at an average speed of 1,5 m.s$^{-1}$ across a bridge from point A to point B and then jogs for 100 m from B to meet Thandi at the jetty at point C. It takes Susie a total time of 3 minutes to get from point A to the jetty at point C.

**Diagram is not to scale**



2.1 Define *distance* and hence state who travels the greater distance in going from A to C. *(Thandi, Susie* or *neither)* (2)

2.2 Define *displacement* and hence state whose displacement from A is greatest upon arriving at C. *(Thandi, Susie* or *neither)* (2)

2.3 Calculate Susie's average speed between B and C. (Give your answer in m.s$^{-1}$) (6)

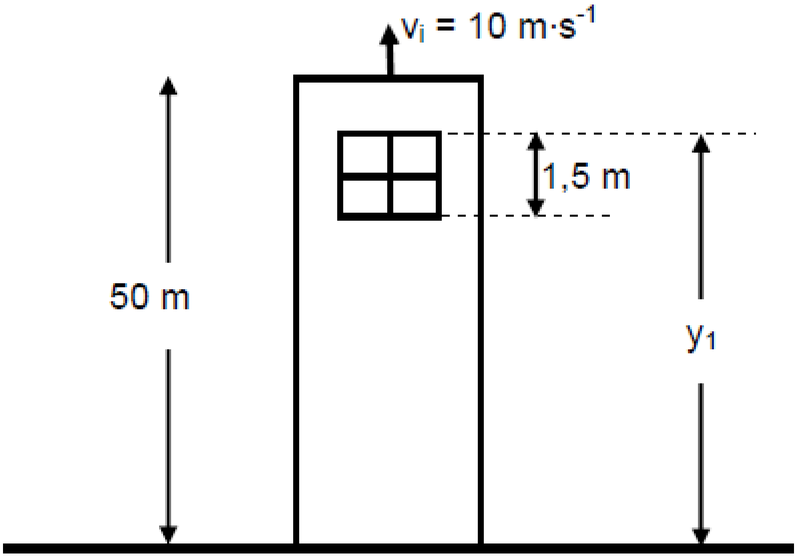
2.4 Calculate Susie's average speed from A to C. (Give your answer in m.s$^{-1}$) (3)

2.5 Calculate the magnitude and direction of Susie's average velocity from A to C. (Give your answer in m.s$^{-1}$) (5)

**[18]**

**QUESTION 3 –** start at the top of a new page

A stone is thrown vertically upward at a velocity of 10 m·s$^{-1}$ from the top of a tower of height 50 m. After some time the stone passes the edge of the tower and strikes the ground below the tower. Ignore the effects of friction.



3.1 Draw a labelled free-body diagram showing the force(s) acting on the stone during its motion. (1)

3.2 Calculate the:

3.2.1 Time taken by the stone to reach its maximum height above the ground (4)

3.2.2 Maximum height that the stone reaches above the ground (4)

3.3 USING THE GROUND AS REFERENCE (zero position), sketch a position-time graph for the entire motion of the stone. (3)

3.4 On its way down, the stone takes 0,1 s to pass a window of length 1,5 m, as shown in the diagram above.

Calculate the distance ($y_1$) from the top of the window to the ground. (7)

**[19]**

**QUESTION 4 –** start at the top of a new page

Bhavik and Balvan have conducted an investigation to determine the coefficient of static friction between two wooden surfaces. They have used the following pieces of equipment during the investigation:

Wooden table top
Wooden block of mass 204,08 g
Various mass pieces of differing masses
Newton spring balance
Light string

4.1 Briefly describe the method that would have been followed that would have produced the following results:

| Mass of block (g) | Normal force (N) | Static friction (N) |
|---|---|---|
| 204,08 | 2,0 | 0,60 |
| 377,55 | 3,7 | 1,10 |
| 551,02 | 5,4 | 1,6 |
| 686,73 | 6,73 | 2,0 |
| 806,12 | 7,9 | 2,3 |

You are strongly advised to describe the method in bullet-point form. (4)

4.2 What is the dependent variable in this experiment? (1)

4.3 What is the independent variable in this experiment? (1)

4.4 Use the graph paper provided on page 17 to plot a graph of the results, placing the normal force on the x-axis and static friction on the y-axis.
You must use more than half the area of the graph paper provided. (6)

4.5 Using the graph, calculate the coefficient of static friction for the wooden surfaces. Show all calculations used. (3)

4.6 How should Bhavik and Balvan adapt their investigation if they were asked to determine the coefficient of dynamic (kinetic) friction instead? (2)

4.7 Would you expect the value of the coefficient of dynamic (kinetic) friction to be **greater** or **smaller** than the coefficient of static friction? (1)

4.8 List and explain a positive everyday application of static friction. (2)

4.9 List and explain a negative everyday application of static friction. (2)

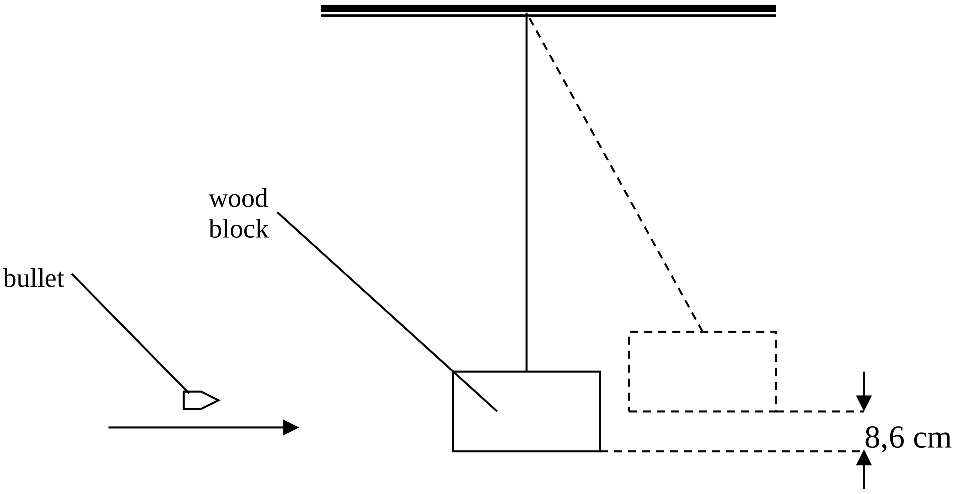
**[22]**

**QUESTION 5** – start at the top of a new page

A bullet of mass 2,0 g is fired horizontally into a block of wood of mass 600 g.

The block is suspended from strings so that it is free to move in a vertical plane.

The bullet buries itself in the block. The block and bullet rise together through a vertical distance of 8,6 cm as shown in the diagram below.



5.1 Calculate the change in gravitational potential energy of the block and bullet. (4)

5.2 Show that the initial speed of the block and bullet, after they began to move off together, was 1,3 m.s$^{-1}$. (5)

5.3 State the *principle of conservation of momentum*. (2)

5.4 Calculate the speed of the bullet before the impact with the block. (5)

5.5 Calculate the kinetic energy of the bullet just before impact. (3)

5.6 State and explain what can be deduced about the type of collision between the bullet and the block. (3)

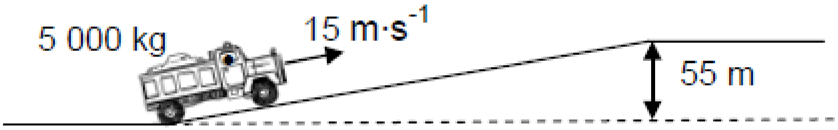
**[22]**

**QUESTION 6 –** start at the top of a new page

A loaded truck with a total mass of 5 000 kg travels up a straight incline at a constant velocity of 15 m.s$^{-1}$. At the top of the incline, the truck is at a height of 55 m above its starting point.

The work done by frictional forces is 8,5 x 10$^{4}$ J.

(Ignore the rotational effects of the wheels of the truck.)



6.1 Define *power* in words. (2)

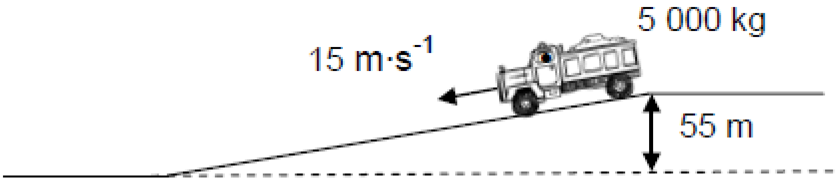
6.2 Draw a labelled free-body diagram showing ALL the forces acting on the truck as it moves up the incline. (4)

6.3 State the *Work-Energy Theorem*. (2)

6.4 Calculate the work done by the engine of the truck to get it to the top of the incline. (3)

6.5 Calculate the average power delivered by the engine of the truck if the truck takes 60 s to reach the top of the incline. (3)

6.6 The truck now returns down the same incline with a constant velocity of 15 m·s$^{-1}$.



How will the work done by the engine of the truck on reaching the bottom of the incline compare to that calculated in QUESTION 6.4?
Write down GREATER THAN, SMALLER THAN or EQUAL TO.
Give a reason for the answer. (2)

**[16]**

**QUESTION 7** – start at the top of a new page

7.1 State which of Newton's Three Laws of Motion best applies to the following situations:

7.1.1 A rock falls off a cliff, and accelerates towards the ground. (1)

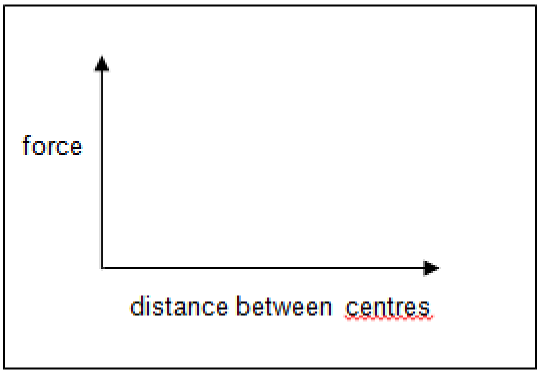
7.1.2 Two physics students give each other a high five. Their hands hurt! (1)

7.1.3 A car is stuck in the snow, spinning its wheels trying to move forward. (1)

7.1.4 A comet moves through deep space at a constant 150 000 km.h$^{-1}$. (1)

7.2 Name and state the law which describes the relationship between the force between two masses and the distance between their centres. (3)

7.3 Copy the diagram below and draw on it the line/curve which shows the relationship between the force between two masses and the distance between their centres. (2)



7.4 Calculate the weight of a man in a space suit (having a combined mass of 110 kg) if he stood on a comet which has a mass of 4 x 10$^{15}$ kg and a diameter of 18 km? (4)

7.5 Describe the "Newton-Pair" of the weight in question 7.4 (i.e. if weight is the action force, what is the reaction force?) (2)

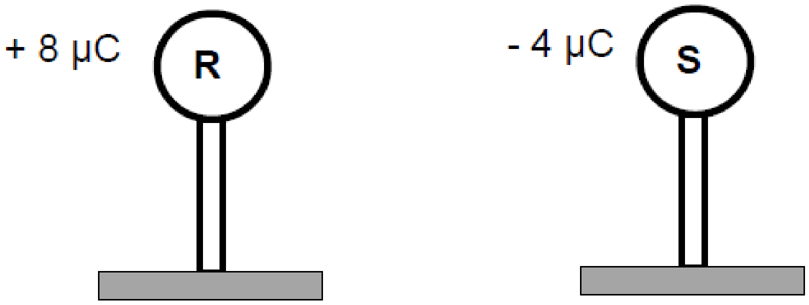
**[15]**

**QUESTION 8 -** start at the top of a new page

The diagram below shows two small identical metal spheres, **R** and **S**, each placed on a wooden stand.

Spheres **R** and **S** carry charges of + 8 μC and - 4 μC respectively.

Ignore the effects of air.



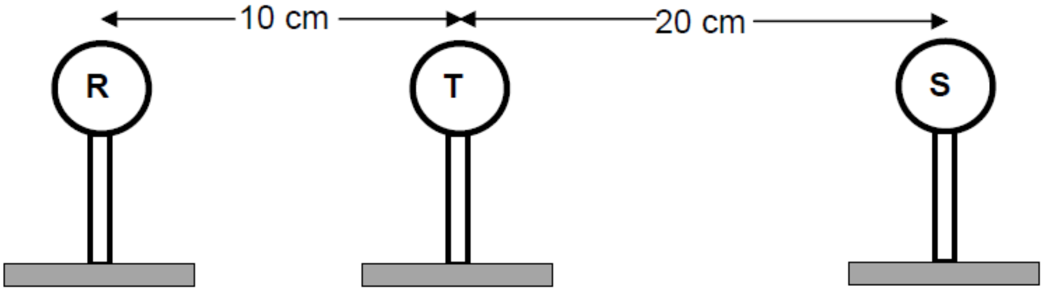
8.1 Explain why the spheres were placed on wooden stands. (1)

Spheres **R** and **S** are brought into contact for a while and then separated by a small distance.

8.2 Calculate the net charge on each of the spheres. (2)

8.3 Draw the electric field pattern due to the two spheres **R** and **S**. (3)

After **R** and **S** have been in contact and separated, a third sphere, **T**, of charge + 1 μC is now placed between them as shown in the diagram below.



8.4 Draw a free-body diagram showing the electrostatic forces experienced by sphere **T** due to spheres **R** and **S**. (2)

8.5 Calculate the net electrostatic force experienced by **T** due to **R** and **S**. (6)

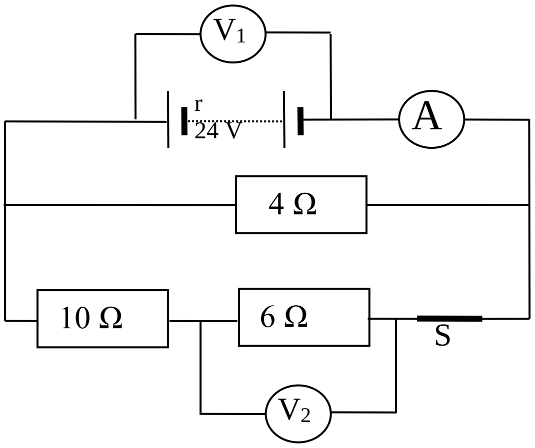
8.6 Define the *electric field at a point*. (2)

8.7 Calculate the magnitude of the net electric field at the location of **T** due to **R** and **S**. (Treat the spheres as if they were point charges.) (3)

**[19]**

## **QUESTION 9 –** start at the top of a new page

A battery of emf 24 V and of internal resistance r is connected in a circuit as shown.



9.1 Prove, by means of calculation, that the effective resistance of the external resistors in the circuit is 3,2 Ω. (3)

9.2 State *Ohm's Law*. (2)

9.3 With switch S closed, the reading on the ammeter is 6 A. Calculate

9.3.1 the reading on voltmeter $V_1$. (4)

9.3.2 the current through the 4 Ω resistor. (4)

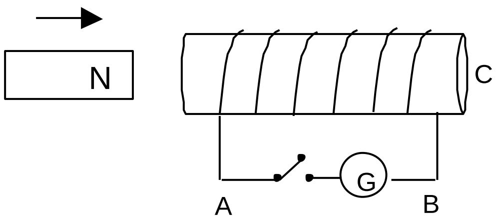
9.3.3 the reading on voltmeter $V_2$. (4)

9.4 Calculate the internal resistance of the battery. (4)

**[21]**

**QUESTION 10** – start at the top of a new page

In the accompanying sketch, the north pole of a bar magnet is moved towards a solenoid connected to a circuit containing a switch and galvanometer.



10.1 State *Lenz's Law*. (2)

10.2 Is a potential difference produced across the switch when it is open? (1)

10.3 Define *magnetic flux linkage*. (2)

10.4 Explain why an emf is induced in the coil. (2)

10.5 State *Faraday's Law of electromagnetic induction*. (2)

10.6 What is the magnetic polarity of the solenoid at C when the switch is closed. (1)

10.7 In what direction does the current flow across the galvanometer when the switch is closed: A to B or B to A? (2)

**[12]**

**QUESTION 11** – start at the top of a new page

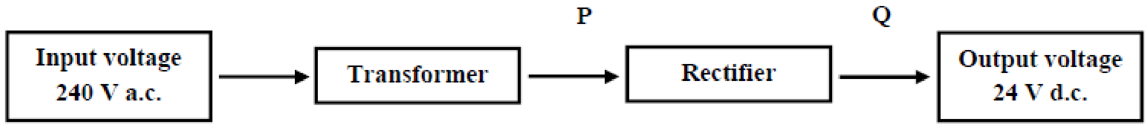
Shaun and Jane have a camping fridge which requires a 24 V d.c. power source. Two 12 V car batteries can be used to provide the required voltage.

11.1 How should the batteries be connected to each other in order to provide the 24 V required by the fridge? (1)

11.2 When the batteries are connected correctly the fridge draws a current of 6 A. Calculate the power input to the fridge. Ignore the internal resistance of the batteries. (3)

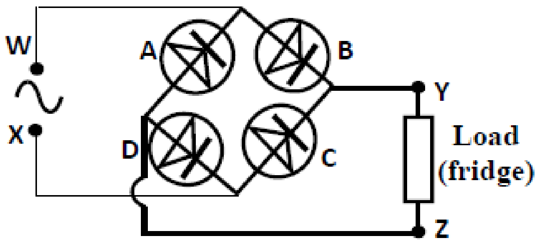
11.3 The fridge can also be connected via a transformer and rectifier to a 240 V a.c. source as shown in the simplified flow chart in Diagram 1 below.

**Diagram 1: Flow chart to show how voltage is changed from 240 V a.c. to 24 V d.c.**



The rectifier consists of a combination of diodes connected as shown in Diagram 2.

**Diagram 2: Arrangement of diodes in rectifier**



11.3.1 What is a *diode*? (2)

11.3.2 What is the function of the rectifier? (2)

11.3.3 Describe the path taken by conventional current in the circuit shown in Diagram 2 **when W is positive**. Indicate which diodes (A, B, C, D) the current passes through and the direction of the current through the load (Y to Z or Z to Y). (3)

11.3.4 What type of transformer (step-up or step-down) is required in Diagram 1? (1)

11.3.5 Ignoring actual values of emf and time, draw sketch graphs to represent the change in emf with time

(a) immediately **before** the current passes through the rectifier (position P on Diagram 1) and

(b) immediately **after** the current passes through the rectifier (position Q on Diagram 1) (4)

**[16]**

**End of Question Paper : Total = 200 marks**

## EXAMINATION DATA SHEET FOR THE PHYSICAL SCIENCES (PHYSICS)

### TABLE 1 PHYSICAL CONSTANTS

| NAME | SYMBOL | VALUE |
|---|---|---|
| Acceleration due to gravity | g | $9{,}8 \text{ m.s}^{-2}$ |
| Speed of light in a vacuum | c | $3{,}0 \times 10^{8} \text{ m.s}^{-1}$ |
| Universal gravitational constant | G | $6{,}7 \times 10^{-11} \text{ N.m}^{2}\text{.kg}^{-2}$ |
| Coulomb's constant | k | $9{,}0 \times 10^{9} \text{ N.m}^{2}\text{.C}^{-2}$ |
| Magnitude of charge on electron | e | $1{,}6 \times 10^{-19} \text{ C}$ |
| Mass of an electron | $m_e$ | $9{,}1 \times 10^{-31} \text{ kg}$ |
| Planck's constant | h | $6{,}6 \times 10^{-34} \text{ J.s}$ |
| 1 electron volt | eV | $1{,}6 \times 10^{-19} \text{ J}$ |

### TABLE 2 PHYSICS FORMULAE

**MOTION**

| | |
|---|---|
| $v = u + at$ **or** $v_f = v_i + a\Delta t$ | $s = \left(\frac{v+u}{2}\right)t$ **or** $\Delta x = \left(\frac{v_f + v_i}{2}\right)\Delta t$ |
| $v^2 = u^2 + 2as$ **or** $v_f{}^2 = v_i{}^2 + 2a\Delta x$ | $s = ut + \frac{1}{2}at^2$ **or** $\Delta x = v_i\Delta t + \frac{1}{2}a(\Delta t)^2$ |

**FORCE AND MOMENTUM**

| | | |
|---|---|---|
| $F_{net} = ma$ | $F_{net} = \frac{\Delta p}{\Delta t}$<br>**or**<br>$F_{net}\Delta t = m\Delta v$ | $\Delta p = mv - mu$<br>**or**<br>$\Delta p = mv_f - mv_i$ |
| $p = mv$ | $w = F_g = mg$ | $F_f^{max} = \mu F_N$ |

**WORK, ENERGY AND POWER**

<table>
<tr><td colspan="4">$W = Fs$ <b>or</b> $W = F\Delta x$ <b>or</b> $W = F\Delta x \cos\theta$</td><td colspan="4">$P = \frac{W}{t}$</td><td colspan="4">$P = Fv$</td></tr>
<tr><td colspan="3">$E_p = mgh$</td><td colspan="3">$E_k = \frac{1}{2}mv^2$</td><td colspan="3">$W_{net} = \Delta E_K$</td><td colspan="3">$efficiency = \frac{power_{out}}{power_{in}}$</td></tr>
</table>

## GRAVITATIONAL AND ELECTRIC FIELDS

| | | |
|---|---|---|
| $F=G\frac{m_1m_2}{r^2}$ | $g=G\frac{M}{r^2}$ | |
| $F=k\frac{q_1q_2}{r^2}$ | $E=\frac{F}{q}$ | $E=\frac{kQ}{r^2}$ |

## ELECTRIC CIRCUITS

| | |
|---|---|
| $I=\frac{Q}{t}$ | $V=\frac{W}{q}$ |
| $R=\frac{V}{I}$ | $emf=I(R_{ext}+r)$ |
| $R_S=R_1+R_2+\ldots\ldots$ | $\frac{1}{R_p}=\frac{1}{R_1}+\frac{1}{R_2}+\ldots\ldots$ |
| $P=\frac{W}{t}$ **or** $W=Pt$ | |
| $W=VIt$ **or** $W=I^2Rt$ **or** $W=\frac{V^2}{R}t$ | |
| $P=VI$ **or** $P=I^2R$ **or** $P=\frac{V^2}{R}$ | |

## ELECTRODYNAMICS

| | |
|---|---|
| $\Phi=BA\cos\theta$ | $emf=-\frac{N\Delta\Phi}{\Delta t}$ |
| $V_pI_p=V_sI_s$ | $\frac{N_s}{N_p}=\frac{V_s}{V_p}$ |

## PHOTONS AND ELECTRONS

| | | |
|---|---|---|
| $c=f\lambda$ | $E=hf$ **or** $E=\frac{hc}{\lambda}$ | |
| $E=W_0+E_{K(max)}$ | $W_0=hf_0$ | $E_{K(max)}=\frac{1}{2}mv_{max}^{2}$ |

**QUESTION 4.4** (6)

**Laundry Number:** ______________________________