AUGUST 2016
GRADE 12
PHYSICAL SCIENCES PAPER 1
PHYSICS

Time: 3 hours **Marks: 200**

EXAMINER: Mr. N. Robert

MODERATOR: Mr. M.J. Green

PLEASE READ THE FOLLOWING INSTRUCTIONS CAREFULLY

1. This paper consists of 23 pages. **This includes a data sheet (pages 21 and 22) and a sheet of graph paper (page 23). These can be detached.**
2. Please check that your question paper is complete.
3. **Write your Laundry Number on the answer sheet (page 23). Detach the answer sheet and insert it into your answer booklet when handing in your script.**
4. Read the questions carefully.
5. Answer ALL the questions.
6. It is in your interest to write legibly and present your work neatly.
7. Question 1 consists of 10 **MULTIPLE- CHOICE questions.**

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~~ (X)	D	Here “C” has been marked as the correct answer

8. Questions in **Section B** must be answered in your answer book.
9. Number your answers exactly as the questions are numbered.
10. Use the data and formulae whenever necessary.
11. Start each question on a new page.
12. Show your working in all calculations
13. Units need not be included in the working of calculations, but appropriate units should be show in the answer.
14. Where appropriate express answers to TWO decimal places.

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

1.1 Four different learners were asked to state Newton's First Law of Motion. Which ONE of the following statements is most correct?

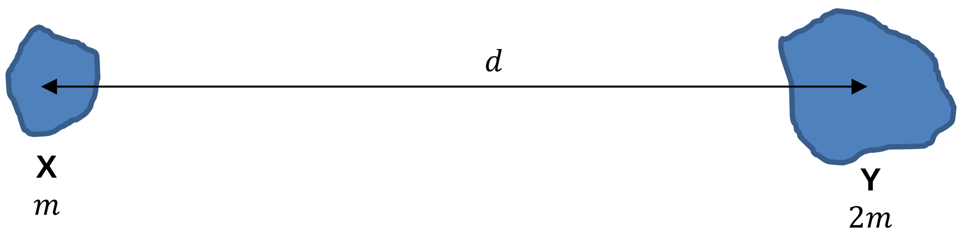
A "Objects resist changes to how they move because of their inertia."

B "Objects resist being in motion which is why they slow down."

C "Only if one force acts on an object will its motion remain constant."

D "Objects tend to remain at rest which is the property of inertia."

1.2 Two asteroids (X and Y) are in deep space. X has mass m and Y has mass $2m$. The distance between their centres of mass is d. The gravitational force experienced by asteroid Y is F.



If the distance between the asteroids is halved, what is the force experienced by asteroid X in terms of F?

A 4F

B 0,25F

C 2F

D 0,5F

1.3 A ball of mass m is thrown towards a wall with speed v and it rebounds with the same speed v. If the force that the wall exerts on the ball during the collision is F, how long did the collision last?

A $\frac{F}{mv}$

B $\frac{F}{2mv}$

C $\frac{mv}{F}$

D $\frac{2mv}{F}$

1.4 An electric car is travelling at a constant speed. The _________ of the car must also be constant.

A momentum

B velocity

C kinetic energy

D mechanical energy

1.5 Ohm's Law only applies when the

A temperature of the conductor is constant

B potential difference across the conductor is constant

C current through the conductor is constant

D conductor is connected in a series circuit

1.6 Which ONE of the following is NOT a unit of energy?

A $\mathbf{N \cdot m^{-1}}$

B $\mathbf{kW \cdot h}$

C $\mathbf{W \cdot s}$

D $\mathbf{kg \cdot m^{2} \cdot s^{-2}}$

1.7 Which of the following are properties of graphite that make it a suitable material to use as brushes in electrical motors and generators?

(i) small coefficient of friction (slippery)

(ii) electrical conductor

(iii) lustrous (shiny)

(iv) high melting point

A (i) and (ii) only

B (ii) only

C (i), (ii) and (iv)

D all of (i), (ii), (iii) and (iv)

1.8 What is the role of a transformer in connecting a generator in a power station to a long-distance transmission line?

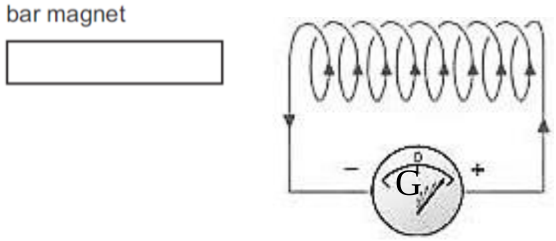
A To reduce heating in the transmission lines by stepping up the current.

B To reduce heating in the transmission lines by stepping up the voltage.

C To increase current in the transmission lines by stepping up the voltage.

D To increase heating in the transmission lines by stepping up the current.

1.9 The image below shows a long coil connected to a galvanometer and a bar magnet which can be moved.



In order for the current to flow in the circuit as shown, how should the bar magnet be orientated and moved?

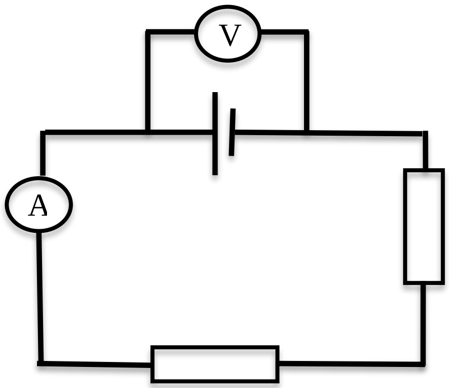
A The north pole should be moved up and down at the entrance to the coil

B The south pole should be moved up and down at the entrance to the coil

C The north pole should be pushed into the coil

D The south pole should be pushed into the coil

1.10 In the circuit diagram shown below the resistances of the ammeter and connecting wires can be ignored. The cell has an emf, and significant internal resistance.



What happens to the readings on the ammeter and voltmeter when a third resistor is added in series with the other two resistors?

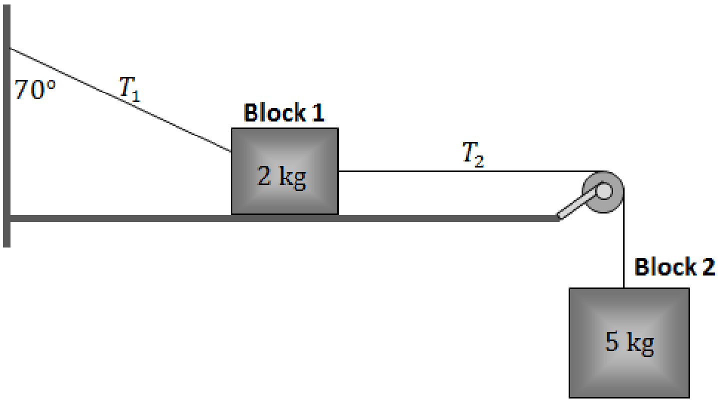
	Ammeter reading	**Voltmeter reading**
A	Increases	Increases
B	Decreases	Stays the same
C	Decreases	Increases
D	Stays the same	Decreases

[2 x 10 = 20]

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

QUESTION 2 Newton's Laws

2.1 Two blocks of different mass are attached to each other via a light inextensible string which is placed over a massless and frictionless pulley. Block 1 (mass 2 kg) is placed on a smooth surface and attached to the wall by a second string which makes an angle of 70° to the vertical as shown in the diagram below. Block 2 (mass 5 kg) is left to hang freely. The entire system is **in equilibrium** and all forms of friction can be ignored.



2.1.1 State Newton's Second Law of Motion. (3)

2.1.2 Draw a free body diagram showing all forces acting on the 2 kg mass. Your diagram need not be perfectly to scale, but should clearly show the **relative sizes and directions** of the forces involved. (4)

[**HINT: 'in equilibrium'** means that a = 0, hence F_{net} = 0]

2.1.3 Determine the Tension force T_2. (3)

2.1.4 Hence, using your free body diagram and your answer in 2.1.3, determine the magnitude of the normal force exerted on the 2 kg mass. (5)

2.2 Two students are arguing about the forces acting when a man pushes a car and the car starts to move forward.

Simon states: "*Newton's third law does NOT hold true once the car starts to move, as the man's force on the car is now causing motion*"

James states: "*Despite the car's motion, Newton's third law still applies.*"

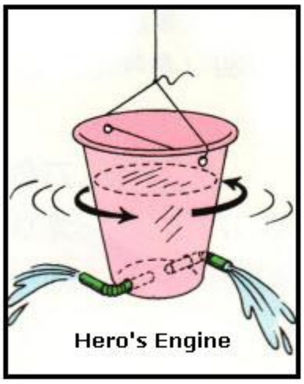
2.2.1 Define Newton's third law of motion. (2)

2.2.2 Whose statement is correct? Explain your answer with reference to the relevant laws of motion and the aid of a suitable force diagram on the car.

[**HINT:** you should consider only two forces for your explanation and force diagram:
Force of man on CAR and
Force of road surface on CAR (friction) (5)

2.2.3 The boys manage to agree that it would be easier to push the car (i.e F_{fmax} is less) by applying a horizontal force rather than a slightly downward directed force. Explain why the boys are correct **using a relevant equation** in your explanation. (3)

A Hero's Engine is a spinning cup which illustrates Newton's 3rd law of motion.

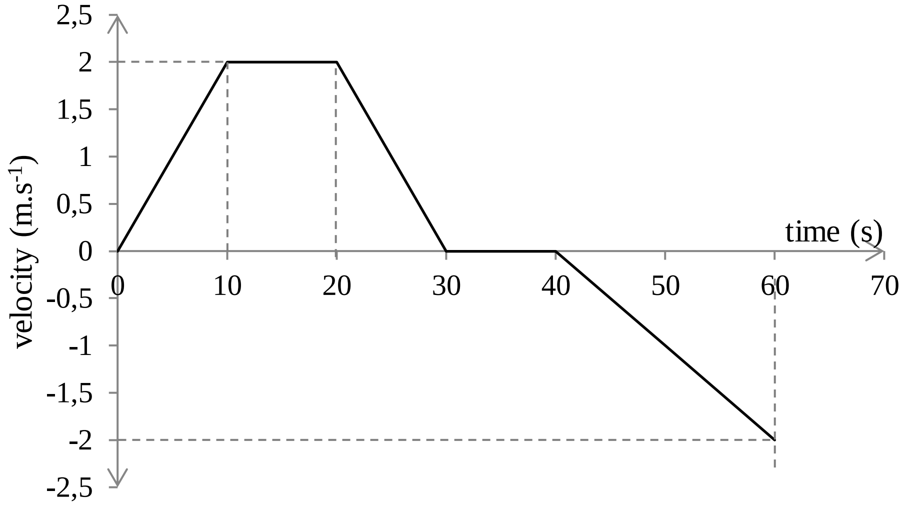


2.2.4 Explain the rotation of the cup which results when the cup is filled with water. (3)

[28]

Question 3 **Kinematics: Graphs and vectors**

3.1 A camera on a rail moves horizontally east and west along the side of a rugby field. The following velocity-time graph shows its motion over a period of 60 seconds. The camera **initially moves east.**



3.1.1 Determine the acceleration of the camera between 40 and 60 seconds. (5)

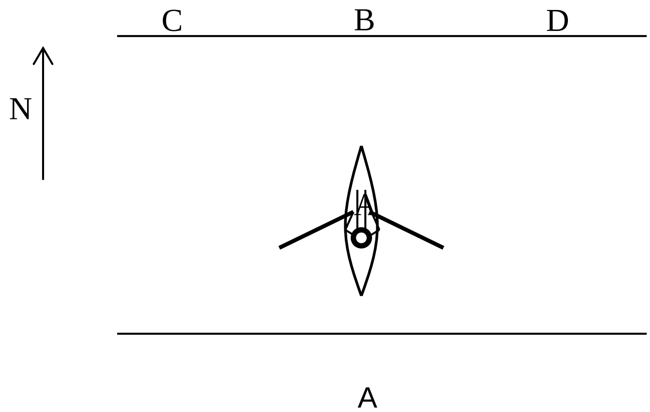
3.1.2 Over which time intervals does the camera experience no net force? (2)

3.1.3 Complete the following statement for the camera's journey. Rewrite the sentence and insert only 'east' or 'west' to make the statement true.

At 60 seconds the camera's position is ________ of its starting position moving ________ (2)

3.2 A rower is able to row in water with a constant velocity of 3 $m.s^{-1}$. He wishes to cross from one side of a river to the other in order to arrive at a point directly north of his starting point (A to B). The water flows west (from D to C) with a velocity of 2,5 $m.s^{-1}$. Points C and D are points along the river bank.

The drawing below is not drawn to scale.



3.2.1 Define the term *resultant vector*. (2)

3.2.2 Determine the magnitude of the resultant velocity of the rower if he manages to cross the river directly from A to B. Include a labelled **vector diagram (triangle of forces)** in your answer.

[3 marks will be awarded to your vector diagram] (6)

3.2.3 Determine the direction in which the rower should paddle his boat in order to achieve his aim of crossing the river directly from A to B.

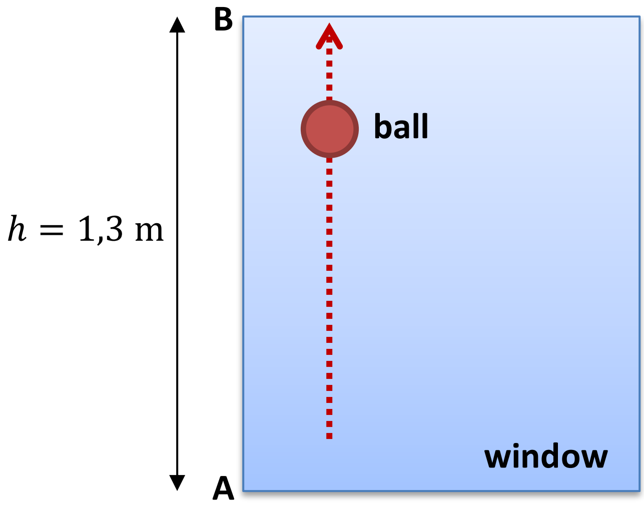
Remember to express this direction in an appropriate manner i.e E of N or N of E or as a bearing. (3)

[20]

Question 4 **Kinematics: Equations of motion, vectors and friction**

4.1 Sean is practicing fielding just outside a tall building. He throws a cricket ball vertically into the air as high as he can from 1,9 m above the ground. Emily is watching from inside the building on the second floor and she sees the cricket ball fly up past the window.

The window has a height of 1,3 m and the ball takes 0,08 s to pass the window. The bottom edge of the window is 4,5 m above the ground. Ignore air resistance.



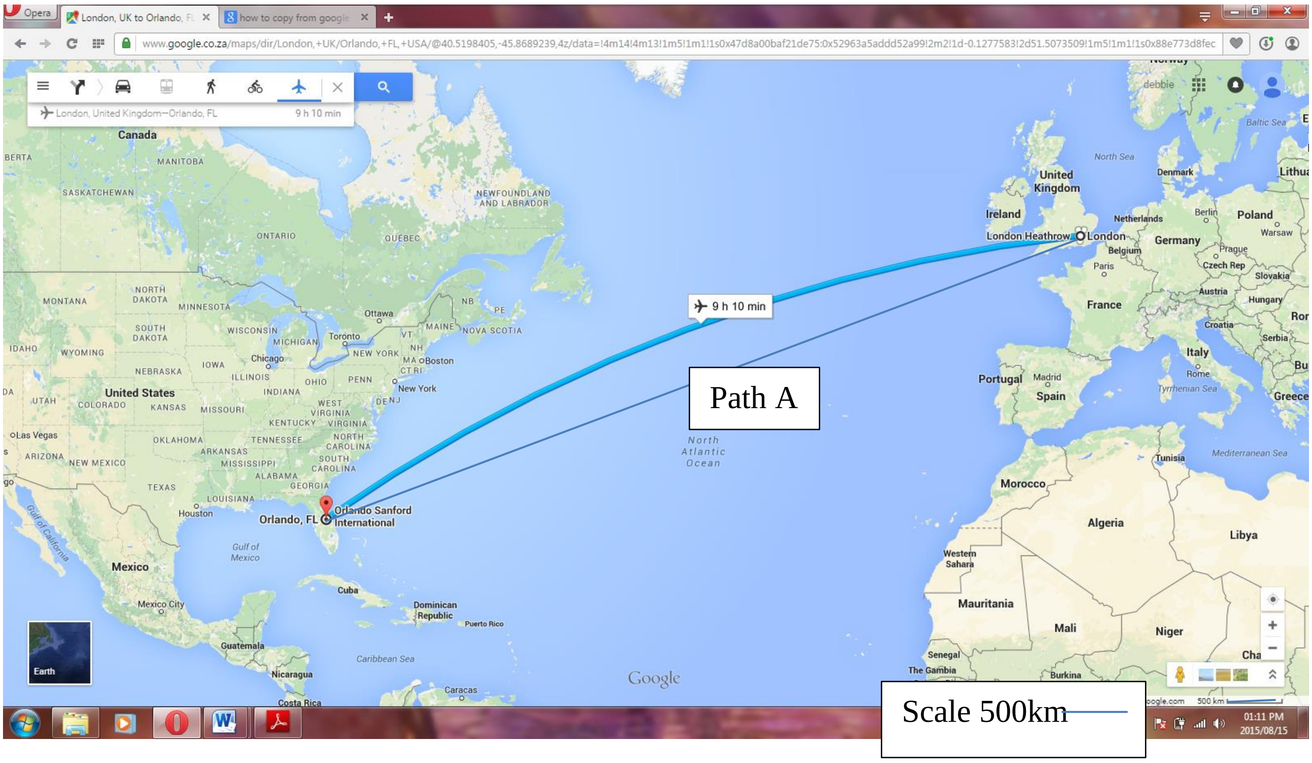
4.1.1 Explain what is meant by the term free fall. (1)

4.1.2 What is the direction of the force acting on the ball while it moves past the window? (1)

4.1.3 Determine the velocity of the ball just as it passes the bottom of the window on its way up (Point A in the diagram). (4)

4.1.4 Determine the height that the ball reaches above its <u>point of release</u>. (5)

4.2 Minnons, Kevin, Stuart and Clive are on a trip to London from the Studios in Orlando, USA. The route taken by the plane is marked on the map (next page). This path is not the most direct path possible. The more direct path is marked “Path A”. The flight takes 9h10mins. The scale for the map is given on the map with the **length of the line drawn representing 500km.**



4.2.1 Give the correct term for Path A, the most direct path. i.e Does Path A represent the distance or displacement. (1)

Using your ruler and the scale of 1cm represents 500 km:

4.2.2 Calculate the <u>magnitude</u> of the average velocity ($m.s^{-1}$) of the plane. (3)

4.2.3 Would you expect the average speed of the plane to be more, less or the same as the average velocity? (1)

4.2.4 Explain your answer in 4.2.3 (2)

On arrival at the airport Kevin, Stuart and Clive acquire a banana and ride off with their prize banana on a London scooter.

Kevin is driving the scooter. He takes off from rest and sees the traffic light just change green at the intersection which is 1500m in front of him. The light will stay green for just **2 minutes**. The scooter's maximum acceleration is 0,25 ms^{-2} and its top speed is 22 ms^{-1}.

4.2.5 Calculate if Kevin manages to reach the traffic light while it is still green? (6)

The Minnons on their scooter travel up a hill with an incline of 15° to the horizontal. The road has significant friction and the engine of the scooter applies a forward force.

The mass of the scooter and all three minions is 95kg and their maximum acceleration up the slope is now 0,12 ms^{-2}. The engine is applying a force of 241 N on the scooter.

4.2.6 What is the force of friction between the road and the tyres of the scooter? Use a free body diagram to help in your calculation. No marks will be awarded for the diagram.

[Remember that F_N will have **three** components] (4)

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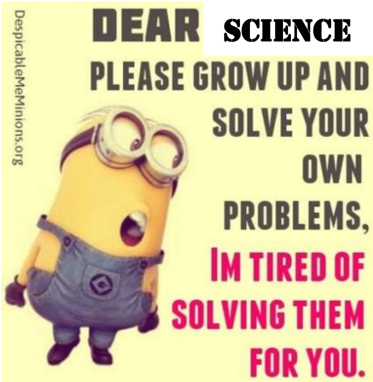
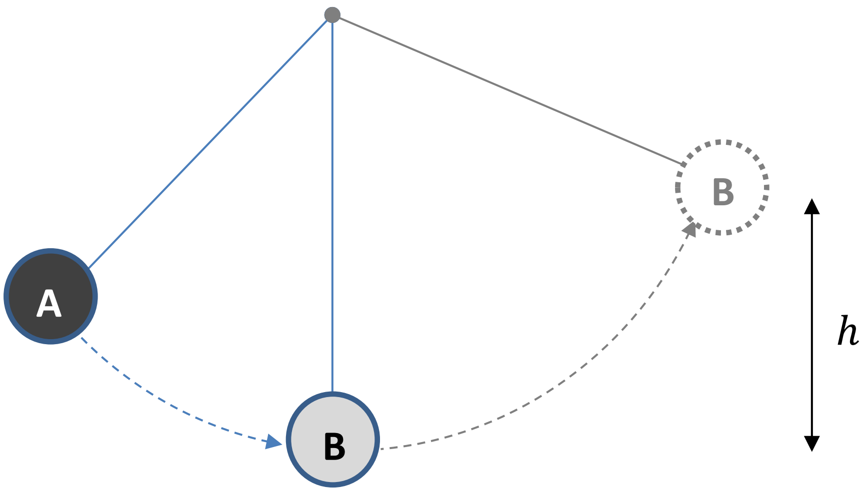


Question 5 **Pendulum**

Mike and Trevor design an experiment to investigate the collision between two pendula. Pendulum A has a mass of $0{,}80\ \mathrm{kg}$ and Pendulum B has a mass of $0{,}65\ \mathrm{kg}$. Pendulum A strikes Pendulum B with a speed of $4{,}5\ \mathrm{m \cdot s^{-1}}$ and follows its original trajectory with a speed of $0{,}5\ \mathrm{m \cdot s^{-1}}$ after the collision. Pendulum B is initially stationary and rises to a height h after the collision. Air resistance and friction between the pendulum and the pivot can be ignored.



5.1 State the principle of conservation of linear momentum in words. (2)

5.2 Calculate the speed of Pendulum B immediately after the collision. (4)

5.3 Perform a suitable calculation to show that the collision is **inelastic**.

[Please round off correctly and substitute appropriately from 5.2.

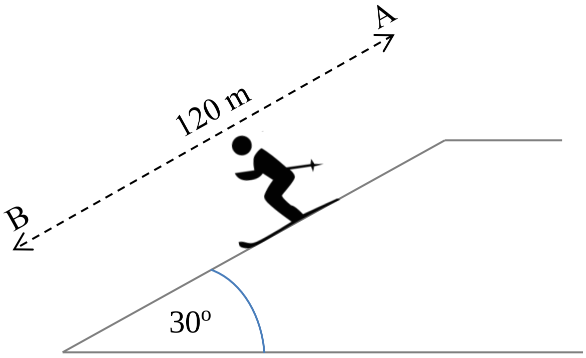
Even if E_{kf} and E_{ki} differ by a very small amount, this will still be significant and the collision inelastic] (6)

5.4 Determine the height h reached by Pendulum B after the collision. (4)

[16]

QUESTION 6 Work energy theorem

A skier, mass 70 Kg, is ready to ski. He started from **rest** at point A (top of slope) and skied down a slope inclined at 30° to the horizontal. He skied straight from point A to point B over a distance of 120 m without his ski poles touching the snow as shown in the diagram below, which is not drawn to scale.



Picture source: http://www.skimybest.com/skisteep.htm

The total kinetic friction between the skis and the slope was 150 N between points A and B.

6.1 Draw a free-body diagram showing all the forces acting on the skier while he was moving down the slope. Name each of the forces and include any relevant angles. (4)

6.2 Determine the component of the skier's weight that acted down the slope. (3)

6.3 Calculate the net work done on the skier as he moved from point A to point B. (5)

6.4 State the *work-energy theorem* in words. (2)

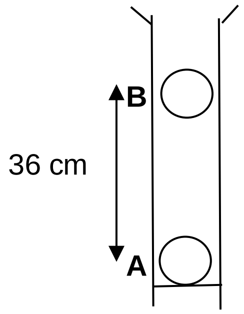
6.5 Hence, determine the magnitude of the velocity of the skier at the bottom of the slope (point B). (4)

[18]

QUESTION 7 GRAPHING AND FIELDS

7.1 Two identical table-tennis balls A and B, each of equal mass 3,0 g are charged positively and placed into a transparent, narrow insulated tube.

The balls are charged such that they repel each other, until ball B hovers, in equilibrium, 36 cm above ball A.



7.1.1 Calculate the weight of each table-tennis ball. **[Answer expressed to 2 significant figures or 3 decimal places]** (3)

7.1.2 State the magnitude of the electrostatic force experienced by ball B. (1)

7.1.3 State *Coulomb's law of electrostatics*. (3)

7.1.4 The two balls initially carry equal positive charges. Show with an appropriate calculation that the charge on each ball is 0,65 µC. (4)

The charge on **ball B** is now changed a number of times and its new equilibrium position above A in the tube is recorded after each change. Charge on ball A remains the same.

The results for the 6 sets of readings are shown in the table below:

Charge on **ball B** (µC)	Distance, r, between A and B (m)	r^2 (m^2)
0,05	0,09	0,008
0,10	0,14	0,020
0,65	0,36	0,130
0,75	0,32	0,102
1,10	0,46	0,212
1,40	0,52	0,270

7.1.5 Identify the independent variable in this investigation. (1)

7.1.6 On the graph paper supplied, on page 23, plot a graph to show the relationship between the distance between the balls squared (r^2) and the charge on ball B (Q_B). (7)
[**HINT:** Draw your graph in landscape orientation.]

7.1.7 Suggest a specific possible cause for the anomalous / outlying point on your graph. (2)

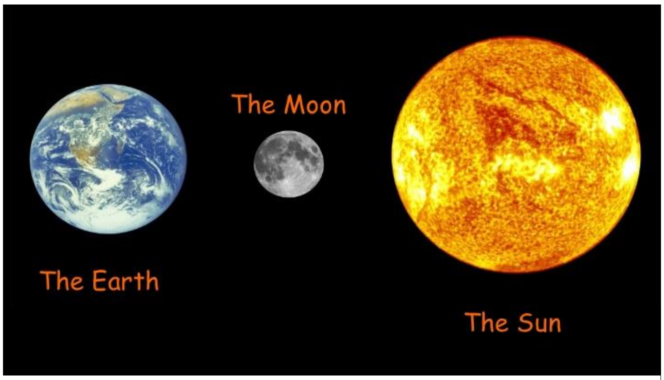
7.1.8 Use your graph to describe the relationship between r^2 and Q_B when Q_A and F_E are constant. (2)

7.2 The mass of the Earth is 6×10^{24} kg and the mass of the Moon is 0,01 times that of the Earth. The distance between the centres of the Earth and Moon is $3,84 \times 10^{8}$ m.

7.2.1 State **Newton's Law of Universal Gravitation** (3)

7.2.2 Calculate the gravitational force of attraction between the Moon and the Earth. (4)

As the Earth, with its Moon, orbits the sun; a "new moon" is observed once a month, when all 3 bodies line up.



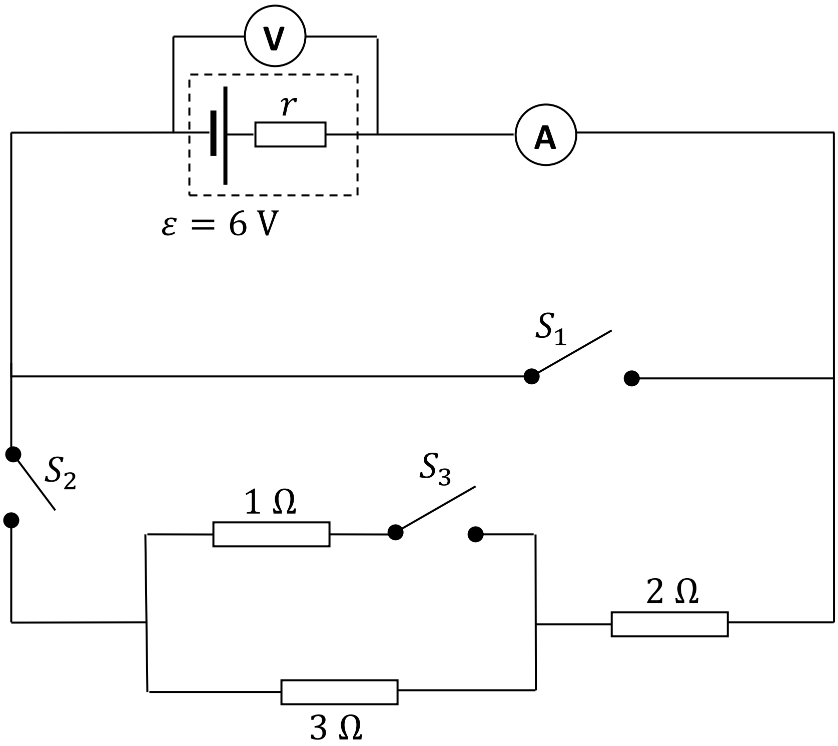
When the "new moon" is observed, the Moon experiences a **net zero gravitational force**.
The mass of the Sun can be taken as $1,9 \times 10^{30}$ kg.

7.2.3 Calculate the distance between the centres of the Sun and the Moon at this time. (4)

[34]

QUESTION 8 Circuits

The circuit in the diagram below consists of three resistors connected as shown, a voltmeter, an ammeter, three switches and a battery of internal resistance r and with an emf of $6\ \mathrm{V}$.



8.1 Define EMF. (2)

8.2 With switch S_2 is closed, S_1 and S_3 are open, the reading on the ammeter is $1{,}091\ \mathrm{A}$. Determine the internal resistance of the battery. (4)

8.3 With switches S_2 and S_3 both closed (S_1 still open), the reading on the ammeter is $1{,}846\ \mathrm{A}$. Calculate the reading on the voltmeter. (3)

8.4 Switch S_1 is replaced with a high-resistance strip of nichrome wire. i.e. switch S_1 is replaced with a resistor and all switches are closed.

8.4.1 How will the temperature of the battery be affected? State only INCREASES, DECREASES or REMAINS THE SAME. (1)

8.4.2 Explain your answer to QUESTION 8.4.1 (3)

[13]

QUESTION 9 Electrodynamics

9.1 A transformer is used to change the 240 V mains AC voltage to the 36 V needed by a 0,5 kW electrical appliance. There are 1000 turns on the primary coil.

9.1.1 Calculate the number of turns in the secondary coil of the transformer. (4)

9.1.2 Assuming 100 % efficiency of the transformer, show that the alternating current in the primary coil is 2,08 A. (3)

9.1.3 Consider the electrical appliance (marked 36 V, 0,5 kW). If the cost of electricity is R1,30 per kWh, calculate the cost to run this appliance for 3 hours. (3)

9.2 A dynamo is a small AC generator attached to the bicycle frame that is usually used to power a bicycle light. Diagram 1 below gives a schematic picture of such a dynamo.

Diagram 1

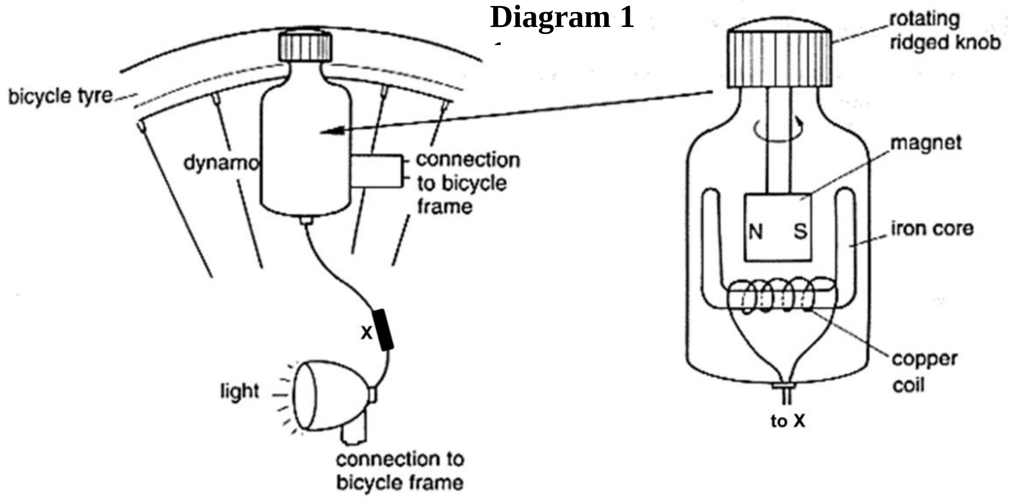


Image adapted from: http://ap-physics.david-s.org/wp-content/uploads/2015/03/dynamo.gif

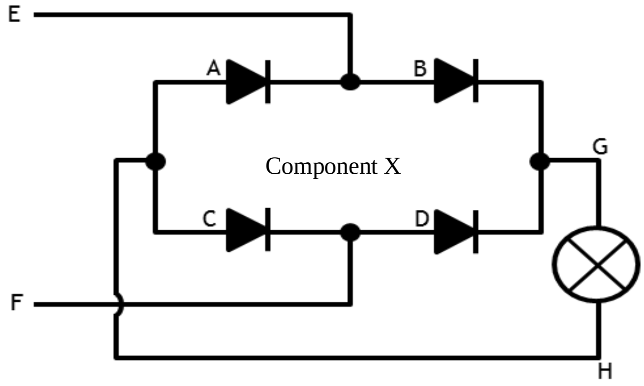
The ridged knob at the top of the dynamo is touched against the rim of the tyre which rotates when the bicycle is moving. This knob is attached to a permanent magnet, which is then rotated in the middle of some coils of wire wound around an iron core.

9.2.1 State the energy conversion that takes place in an AC generator. (1)

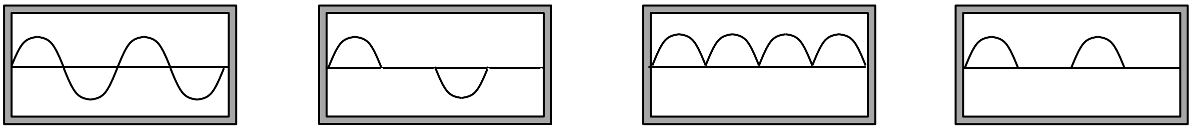
9.2.2 Identify and use an appropriate law of Physics to explain why it is necessary for the permanent magnet to be rotated inside the dynamo. (3)

The dynamo generates an alternating current, but the bicycle light requires direct current to function. As a result, the circuitry (see Diagram 2 below) includes component X, which is a bridge rectifier, to rectify the current.

Diagram 2



The four graphs below show possible read-outs of an oscilloscope, which is a device that displays a graph of voltage as a function of time.



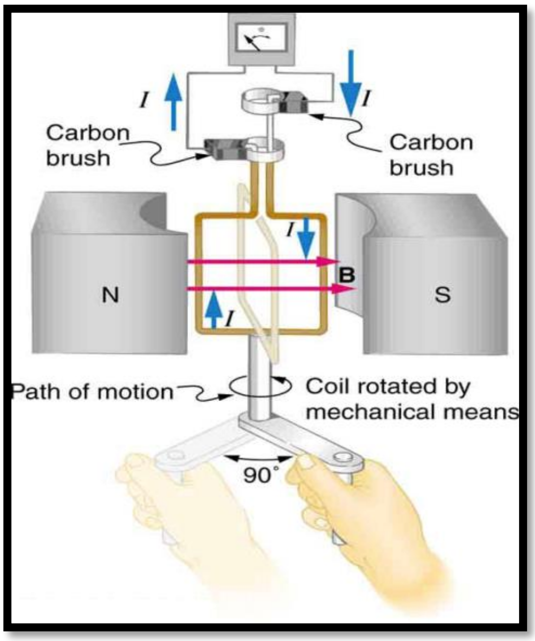
Graph (i) Graph (ii) Graph (iii) Graph (iv)

9.2.3 Give the number of the graph that would be observed if an oscilloscope were connected in the circuit instead of the lightbulb. (1)

9.2.4 Using the necessary letters shown on Diagram 2 above, indicate the full path taken by conventional current through the circuit when **F is positive.** Start with F. (2)

9.2.5 What could the bicycle rider do to make this bicycle light shine more brightly? (1)

9.3 In real life, electric generators look quite different to the diagram below, but the principles are the same. The source of mechanical energy that turns the coil can be falling water (hydropower) or steam (from burning of fossil fuels) or kinetic energy from wind.



9.3.1 What type of current (ac or dc) is generated by the device illustrated on the previous page? Explain your answer. (2)

9.3.2 Sketch the induced emf vs time graph for a single rotation of this coil, beginning with the coil in the position shown in bold on this diagram. (3)

[23]

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

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

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

WORK, ENERGY AND POWER

$W = Fs$ **or** $W = F\Delta x$ **or** $W = F\Delta x \cos\theta$	$P = \frac{W}{t}$	$P = Fv$	
$E_p = mgh$	$E_k = \frac{1}{2}mv^2$	$W_{net} = \Delta E_K$	$efficiency = \frac{power_{out}}{power_{in}}$

GRAVITATIONAL AND ELECTRIC FIELDS

$F = G\frac{m_1 m_2}{r^2}$		$g = G\frac{M}{r^2}$
$F = k\frac{q_1 q_2}{r^2}$	$E = \frac{F}{q}$	$E = \frac{kQ}{r^2}$

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

$\Phi = BA\cos\theta$	$emf = -\frac{N\Delta\Phi}{\Delta t}$
$V_p I_p = V_s I_s$	$\frac{N_s}{N_p} = \frac{V_s}{V_p}$

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 7.1 **Laundry Number: ___________________**