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NAME: _____ SET: _____

St Andrew's College & Diocesan School for Girls**GRADE 12****PHYSICAL SCIENCES: PAPER 1 (PHYSICS)**

Date: Thursday 19 July 2018
Time: 08h00

Examiner: AC Smith
Moderator: K Cobbing

Duration: 3 hours

200 marks

READ THE FOLLOWING INSTRUCTIONS CAREFULLY:

1. Write your name on the front cover of all answer booklets that you use and on your question paper.
2. Please check that your paper is complete:
 - This question paper has SIXTEEN pages, including this coversheet.
 - There should be a loose, double-sided **data sheet** provided on coloured paper as an insert in this question paper.
 - You are to write all your answers in the answer booklet provided, completing Question 1 on the grid provided on the grid provided on the insert and question 8.1 on the graph paper provided on the insert.
3. Please hand in your question paper as well as your answer booklet.
4. Read the questions carefully.
5. Present your work neatly and legibly.
6. Answer ALL the questions.
7. You may answer the questions in any order, but you are to start each question on a new page.
8. Number your answers exactly as the questions are numbered.
9. All working must be shown and units must be given with answers.

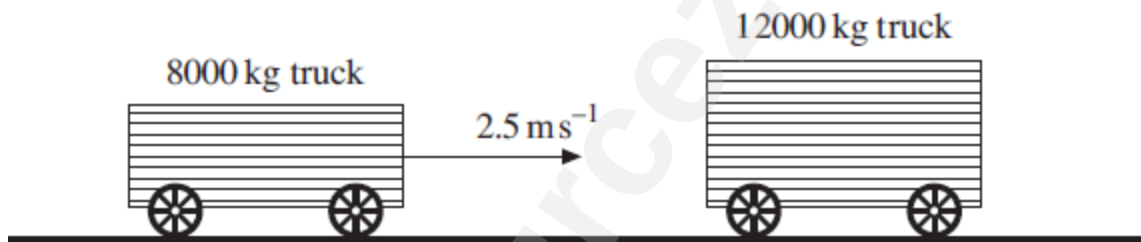
QUESTION 1 MULTIPLE CHOICE QUESTIONS

On your ANSWER SHEET indicate with a cross (X) the letter that corresponds to the correct answer for each of these questions. 10 x (2) marks

1.1 Which of the following are vectors?

- | | | |
|---------------------------------|-----------------|-----------------|
| i. Electric field strength | ii. Charge | iii. Force |
|---------------------------------|-----------------|-----------------|
- A. i only
 B. iii only
 C. i and iii
 D. ii and iii

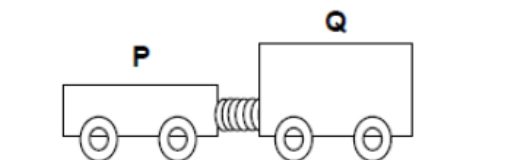
1.2 A railway truck of mass 8000 kg travels along a level track at a velocity of $2,5 \text{ m.s}^{-1}$ and collides with a stationary truck of mass 12000 kg. The two trucks move together with the same velocity after the collision.



What is the magnitude of the velocity of the trucks after the collision ?

- A. 1 m.s^{-1}
 B. $1,67 \text{ m.s}^{-1}$
 C. $2,5 \text{ m.s}^{-1}$
 D. 0 m.s^{-1}

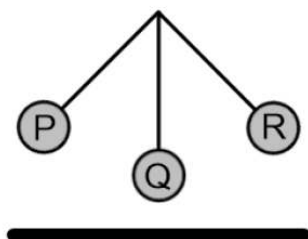
1.3 Two trolleys P and Q, of mass m and $2m$ respectively are at rest on a frictionless horizontal surface. The trolleys have a compressed spring between them. The spring is released and the trolleys move apart.



Which one of the following statements is true?

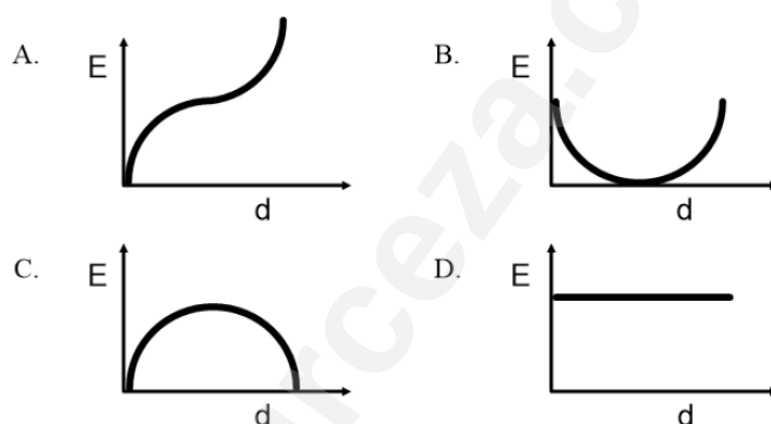
- A. P and Q have equal kinetic energies
 B. The speed of P is less than the speed of Q
 C. The sum of the final kinetic energies of P and Q is zero
 D. The sum of the final momenta of P and Q is zero

- 1.4 A pendulum starts from rest at P and swings freely to point R. Air resistance is negligible. The diagram below shows the swing of the pendulum:

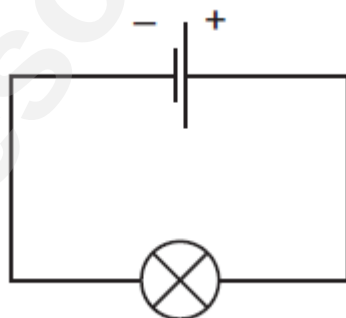


Which graph below best represents the **total mechanical energy (E)** of the pendulum as it moves a distance **d** from P to Q to R?

DOE



- 1.5 A cell is connected to a lamp as shown.



A charge of 4,0 C flows through the lamp in 2,0 s.

What is the direction of the electron flow through the lamp and what is the current through the lamp?

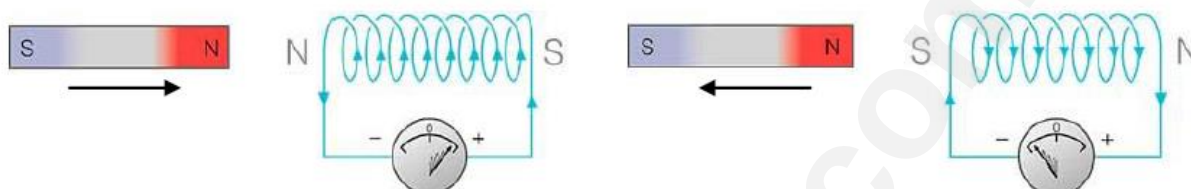
	Direction of electron flow through the lamp	Current through the lamp (A)
A	Left to right	2,0
B	Left to right	8,0
C	Right to left	2,0
D	Right to left	8,0

P.T.O

1.6 Emf is defined as the

- A. voltage across the battery when no current is flowing in a circuit
- B. voltage across the battery when current is flowing in a circuit
- C. work done per unit positive charge applied to the circuit
- D. total energy supplied per coulomb of charge by the cell.

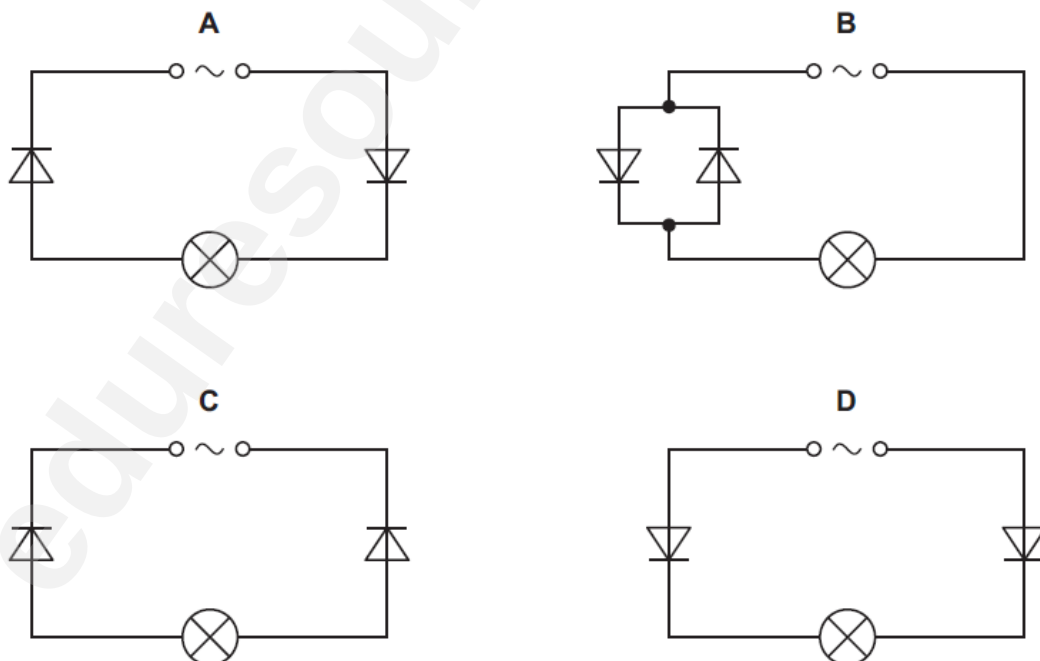
1.7 The diagrams below illustrate an experiment to investigate the direction of the induced current.



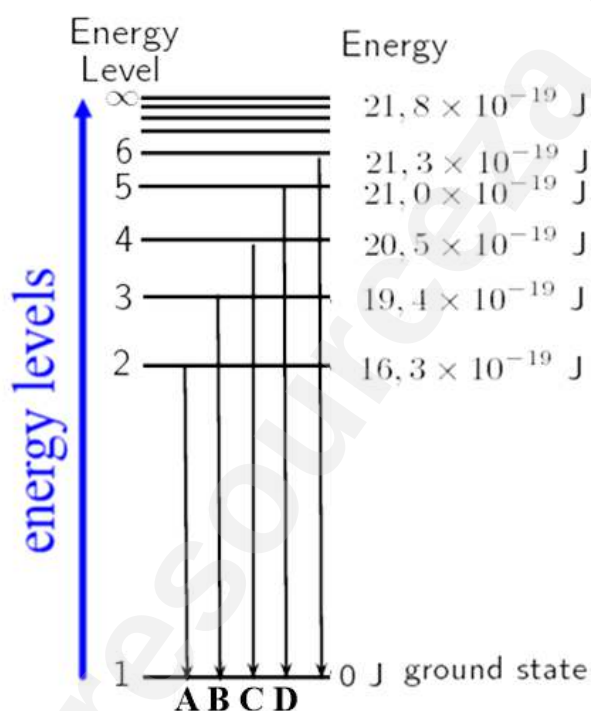
This is ...

- A. the Law of Electromagnetism.
- B. the Law of Electromagnetic Induction.
- C. Lenz's law.
- D. Faraday's law.

1.8 The four circuits shown all include an a.c. power supply, two diodes and a lamp. In which circuit is there a rectified current in the lamp?



- 1.9 Nasa launch a rocket from the earth's surface. By the time the rocket reaches a height of twice the earth's radius above its surface, it has lost half its mass due to the usage of rocket fuel. If the magnitude of the weight of the rocket on the earth's surface is **W**, what is its new weight at this height?
- A. $W/18$
 B. $W/6$
 C. $2W/3$
 D. $2W/9$
- 1.10 An excited hydrogen atom returns to its ground state. Which of the transitions below (A, B, C or D) will release a photon with a frequency of $3,11 \times 10^{15}$ Hz.



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P.T.O.

QUESTION 2**KINEMATICS****(START THIS QUESTION ON A NEW PAGE)**

The Square Kilometre Array is a network of 200 radio telescopes that is being built in the Karoo. The first 64 radio telescopes (known as Meerkat) have been installed and were inaugurated on 13 July 2018.



<http://www.ska.ac.za/gallery/meerkat/>

The site of the SKA is 93,10 km from the town of Carnarvon by road. The SKA lies 65 km West and 28 km North of Carnarvon.



- 2.1 Calculate the displacement (in km) of the SKA site from Carnarvon (to 2 decimal places). (5)

The dishes for the radio telescopes are 12 m in diameter. A dish is transported from Carnarvon to the SKA site on the back of a truck. The trip takes 4,655 hours. (4 hours 39,3 minutes).

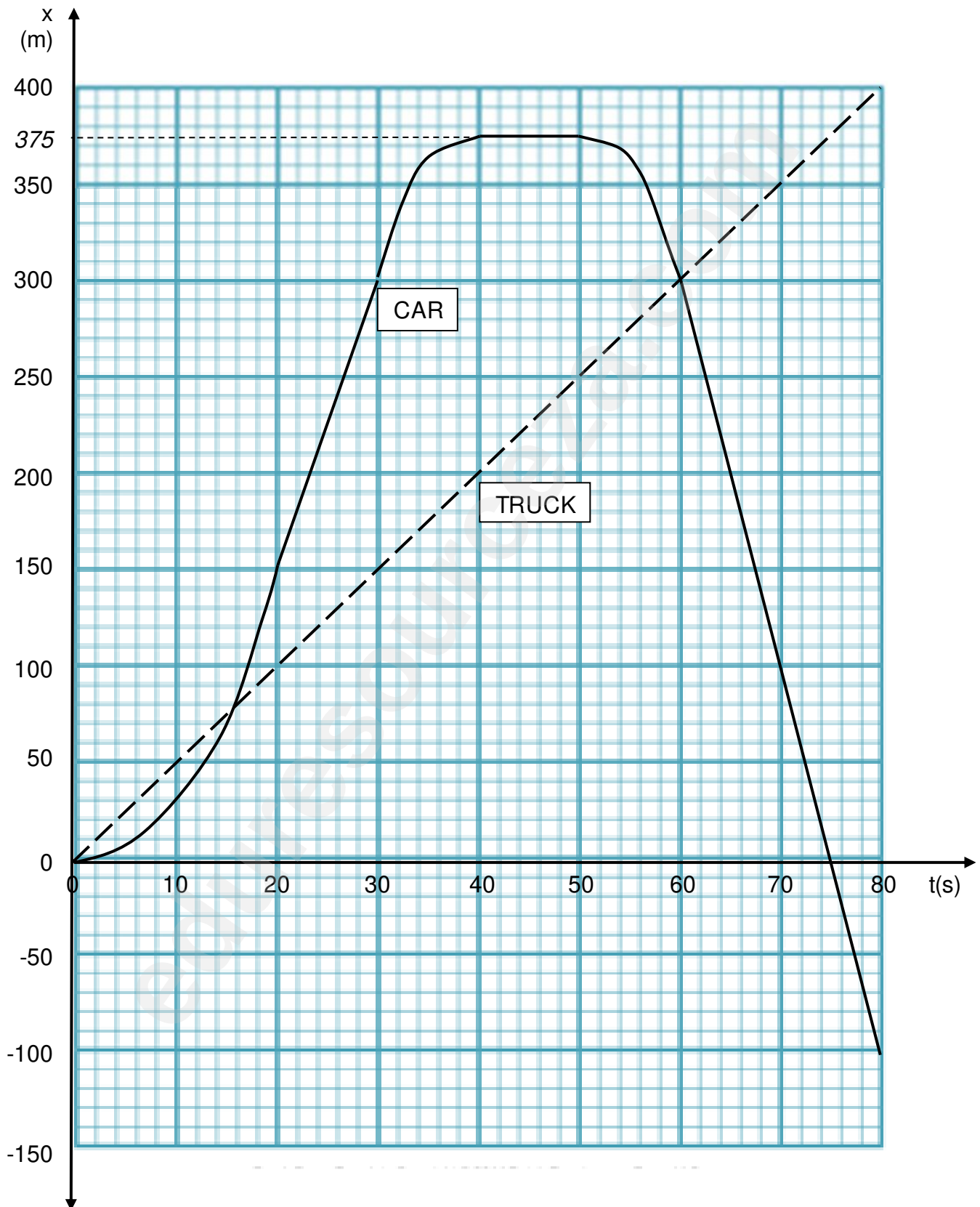
- 2.2 Calculate the average velocity (in km/h) of the truck (to two decimal places). (4)

- 2.3 Calculate the average speed (in km/h) of the truck (to two decimal places). (3)

P.T.O.

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While the truck travels at a constant velocity, a car is escorting the truck along a straight part of the road which is headed **North**. The position – time graphs for both the truck (dashed line) and the car (solid line) are given below.



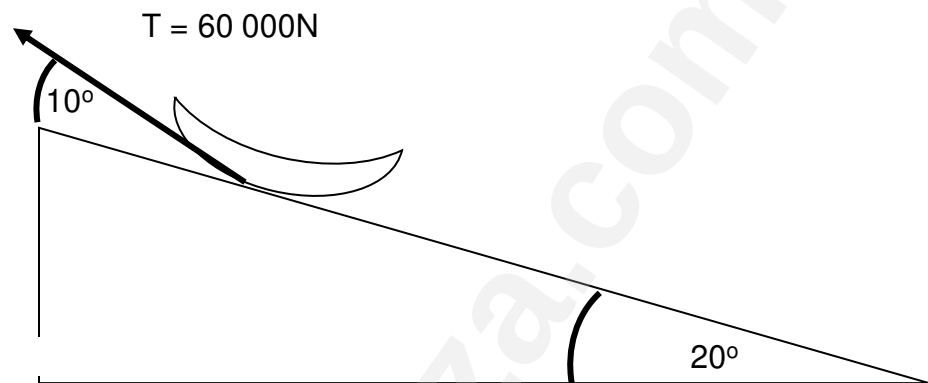
- 2.4 With what constant velocity is the truck moving over the 80 s period? (3)
- 2.5 Explain, with reference to a law of physics, why it is ideal for the truck to move at a constant velocity and not accelerate and brake unnecessarily. (2)
- 2.6 At what time(s) are the car and truck alongside one another? (3)
- 2.7 What is the displacement of the car relative to the truck at 30 s? (2)
- 2.8 What is the velocity of the truck relative to the car at 26 s? (4)
- 2.9 What is the car doing between 40 s and 50 s? (1)
- 2.10 Define *acceleration*. (2)
- 2.11 Calculate the acceleration of the car between:
- 2.11.1 0 s and 20 s (assume the car started from rest) (4)
- 2.11.2 30 s and 40 s. (4)
- 2.12 Describe the motion and position of the car between 60 s and 80 s. (2)
- 2.13 Draw an acceleration – time graph for the motion of the car over the full 80 s. Indicate values clearly on both axes. (7)

[46]**P.T.O.**

QUESTION 3**NEWTON'S LAWS****(START THIS QUESTION ON A NEW PAGE)**

On arrival at the SKA site, the dish is offloaded from the back of the truck by sliding it down a ramp which has a rough surface at 20° to the horizontal. The mass of the dish is 30 tonnes. (1 tonne = 1000 kg)

The dish is kept stationary by a cable which is at 10° to the ramp. The tension in the cable is 60 000N.



- 3.1 Draw a labelled free body diagram of all the forces acting on the dish. (4)
- 3.2 Firstly, calculate the magnitudes of the components of the weight of the dish which are:
 - 3.2.1 parallel to the ramp (to the nearest newton) (2)
 - 3.2.2 perpendicular to the ramp (to the nearest newton). (2)
- 3.3 Secondly, calculate the magnitude of the perpendicular components of the tension in the cable. (4)
- 3.4 Calculate the frictional force acting up the slope. (4)
- 3.5 Hence, find the co-efficient of friction that is acting between the ramp and the dish. (answer to two decimal places) (4)

The cable snaps and the dish accelerates down the slope for 36 m in 6 s.

- 3.6 Calculate the magnitude of the acceleration of the dish as it slides down the ramp. (3)
- 3.7 Define *Newton's Second Law*. (2)
- 3.8 What net force is the dish experiencing? (3)
- 3.9 Calculate the frictional force acting on the dish as it slides down the ramp. (4)
- 3.10 Explain why the frictional force is different from the value you got in Q 3.4. (2)
- 3.11 State the *Work-Energy Theorem*. (2)
- 3.12 Use the Work-Energy Theorem to calculate the velocity of the dish at the bottom of the ramp. (4)

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QUESTION 4**WORK, ENERGY, POWER****(START THIS QUESTION ON A NEW PAGE)**

A crane is lifting one of the radio telescope's dishes vertically upwards in order to fix it on its pedestal.



The dish has a mass of 30 tonnes and is raised a vertical height of 10m in 200 seconds at a constant velocity.

- 4.1 Define *The Principle of Conservation of Mechanical Energy*. (2)
- 4.2 Calculate the gain in gravitational potential energy of the dish as it is lifted at constant velocity to a height of 10m. (3)
- 4.3 Calculate the power of the crane as it lifts the dish. (3)

A hammer of mass 1 kg was left on the dish. It falls off the stationary dish from a height of 10 m above the ground. It hits the ground and bounces upwards with a speed of 4 m.s^{-1} .

- 4.4 Calculate the impulse experienced by the hammer. (6)
- 4.5 Was the collision between the hammer and the Earth elastic or inelastic? Explain your answer. (2)
- 4.6 State the *Principle of Conservation of Linear Momentum*. (2)
- 4.7 Was momentum conserved when the hammer hit the Earth. Explain your answer. (2)
- [20]**

P.T.O.

QUESTION 5 GRAVITATIONAL AND ELECTRIC FIELDS

(START THIS QUESTION ON A NEW PAGE)

The SKA shares data with radio telescopes in Australia via a satellite which is a distance of 6 times the radius of the Earth above the surface of the Earth. The radius of the Earth is 6 300 km. The Earth has a mass of 6×10^{24} kg, and the satellite has a mass of 1000 kg.

- 5.1 State *Newton's Law of Universal Gravitation*. (2)
- 5.2 Calculate the force of gravitational attraction between the Earth and the satellite. (4)
- 5.3 Calculate the gravitational field strength experienced by the satellite. (3)

Assume that the SKA metal dishes are insulated from the Earth and become charged due to dry wind blowing over them and the photoelectric effect. Two dishes (X and Y) are 150m apart and both become positively charged with 650 nC and 450 nC, respectively.

- 5.4 Draw the electric field lines between the two dishes. Carefully label the dishes (X and Y). (3)
- 5.5 State *Coulombs Law*. (2)
- 5.6 Calculate the electrostatic force between the two dishes. (4)

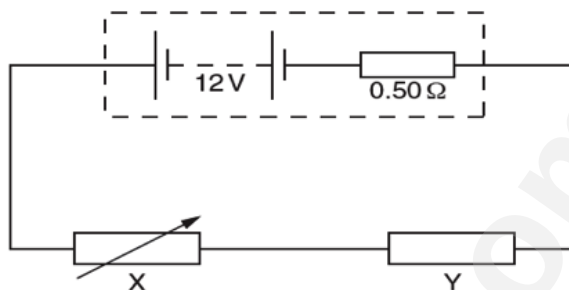
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QUESTION 6

(Beaulieu Trial Exam P1 2016)

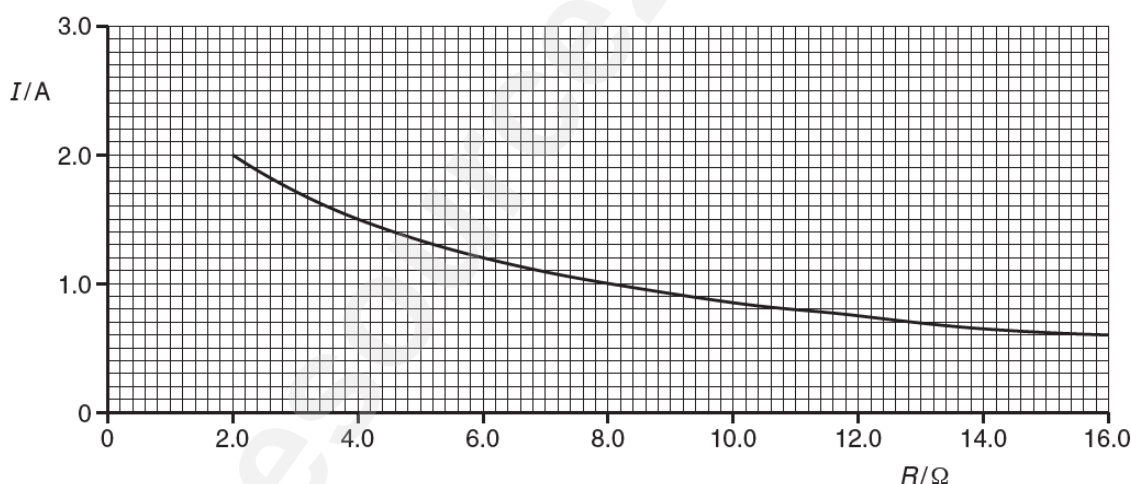
ELECTRIC CIRCUITS**(START THIS QUESTION ON A NEW PAGE)**

A battery of emf 12 V and internal resistance $0,50 \Omega$ is connected to a variable resistor X and a resistor Y of constant resistance, as shown in the figure below.



- 6.1 The cell with internal resistance supplies a current. Explain why the terminal (external) potential difference is less than the emf of the cell. (2)

The resistance R of X is increased from $2,0 \Omega$ to 16Ω . The variation with R of the current I in the circuit is shown on the graph below.



- 6.2 If the current in the circuit is 1,2 A: (1)
- 6.2.1 find the resistance X (1)
- 6.2.2 calculate the potential difference across X (3)
- 6.2.3 calculate the resistance of Y (6)
- 6.2.4 the power dissipated in the battery. (3)
- 6.3 How can the graph be used to explain the variation in the potential difference of the battery as the resistance R of X is increased? (3)
- 6.4 An electric heater is rated 240 V and 2000 W. How much does it cost to run the heater for 5 hours, if the electricity costs R1,17 per kWh. (4)

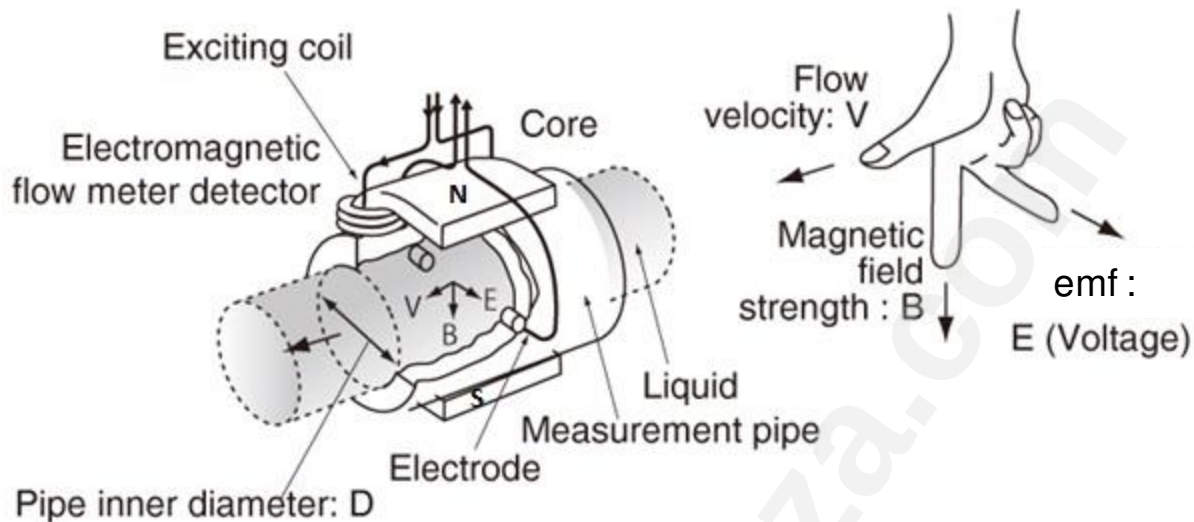
[22]**P.T.O.**

QUESTION 7

(St Henry's Marist Trial P1 2016)

ELECTRODYNAMICS**(START THIS QUESTION ON A NEW PAGE)**

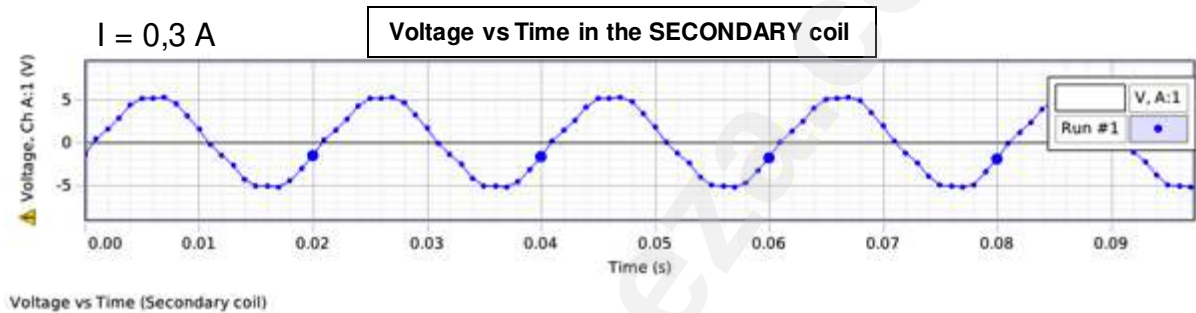
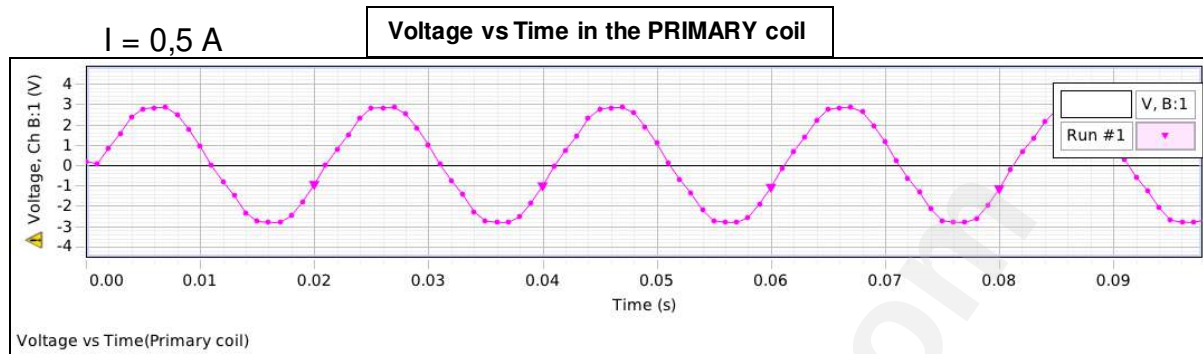
7.1 Magnetic flow meters are used to determine the flow of liquid through a pipe.



In a magnetic flowmeter, a magnetic field is set up across the liquid flowing through the pipe. The flow of a conductive (charged) liquid through the magnetic field will cause an emf to be induced which is sensed by electrodes located on the flow tube walls.

- 7.1.1 State the law that governs the operation of the magnetic flowmeter. (2)
- 7.1.2 State what happens to the voltage when the liquid flows faster. (2)
- 7.1.3 It is said that one can use liquids such as acid, unpurified water within a magnetic flowmeter but not de-ionised water or hydrocarbons. Suggest a possible reason for this. (2)

- 7.2 The graphs below indicate the Voltage vs Time relationship for both primary and secondary coils of a transformer. Examine the graphs and answer the questions below.



- 7.2.1 There are 200 turns in the primary coil. Using the graphs, calculate the number of turns in the secondary coil. (4)
- 7.2.2 Is this a step-up or step-down transformer? (1)
- 7.2.3 Would this transformer be 100% efficient? Explain your response using the necessary calculations. (5)

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P.T.O.

QUESTION 8**Photoelectric Effect**

(Trinityhouse Trial Exam P1 2016)

(START THIS QUESTION ON A NEW PAGE)

Electromagnetic radiation of varying frequency is shone on the sodium metal cathode of a photocell. The maximum kinetic energy of the photoelectrons emitted is recorded.

Table to show how the maximum kinetic energy (E_k) of a photoelectron emitted from sodium metal varies with the frequency (f) of the electromagnetic radiation.

Frequency ($\times 10^{14}$ Hz)	Maximum kinetic energy (eV)
7	0,59
8	1,00
9	1,42
10	1,83

- 8.1 Plot a graph of maximum kinetic energy vs frequency as represented by these results for sodium metal. Use the GRAPH PAPER PROVIDED on your Answer Sheet. The scale on the y-axis has been marked for you. You must fill in your own scale for the x-axis which must start at ZERO. (6)
- 8.2 According to the table above, radiation of a particular frequency causes a photoelectron to be emitted with the maximum kinetic energy of 1,00 eV. Hence, determine:
- 8.2.1 the **frequency** of this radiation incident on the sodium metal cathode. (1)
- 8.2.2 the **energy (in joules)** of this radiation incident on the sodium metal cathode. (3)
- 8.3 **Read** off the threshold frequency for the sodium metal from the graph you plotted. (2)
- 8.4 The magnitude of the value given by the y-intercept is equal to the work function (W_f) of the metal.
- 8.4.1 Extend your graph backwards to cut the y-axis and hence read off the work function of the sodium metal (in eV). (1)
- 8.4.2 Convert your answer in question 8.4.1 to joules. (1)
- 8.5 When the 9×10^{14} Hz radiation shines on the sodium metal the maximum kinetic energy of the ejected electrons is $2,27 \times 10^{-19}$ J.
- 8.5.1 Calculate the maximum speed of the ejected electrons. (3)
- 8.5.2 How would the speed of the electrons change if the radiation **intensity was doubled** but the frequency remained the same? Write only INCREASE, DECREASE or REMAINS THE SAME (1)

[18]