NATIONAL SENIOR CERTIFICATE EXAMINATION
NOVEMBER 2019

PHYSICAL SCIENCES: PAPER I

Time: 3 hours | 200 marks

PLEASE READ THE FOLLOWING INSTRUCTIONS CAREFULLY

1. This question paper consists of 16 pages, an Answer Sheet of 2 pages (i–ii), and a Data Sheet of 2 pages (i–ii). Please check that your question paper is complete.
2. Answer ALL the questions.
3. Read the questions carefully.
4. Use the data and formulae whenever necessary.
5. Start each question on a new page.
6. Number your answers as the questions are numbered.
7. Show your working in all calculations.
8. Units need not be included in the working of calculations, but appropriate units should be shown in the answer.
9. Answers must be expressed in decimal format, not left as proper fractions.
10. Where appropriate express answers to TWO decimal places.
11. It is in your own interest to write legibly and to present your work neatly.

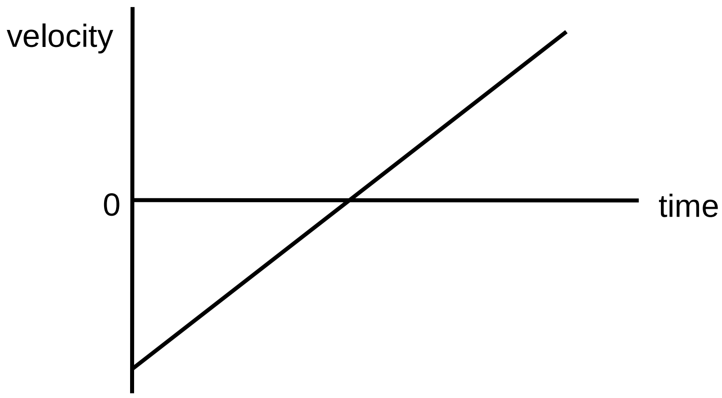
QUESTION 1 MULTIPLE CHOICE

Answer these questions on the multiple-choice answer sheet on the inside front cover of your Answer Book. Make a cross (X) in the box corresponding to the letter that you consider to be correct.

1.1 Which row shows a physical quantity and a **correct** unit?

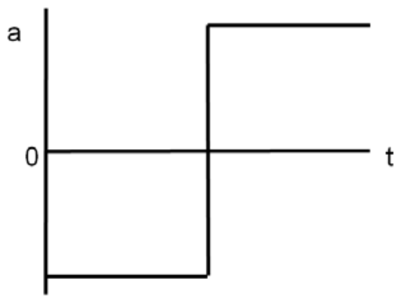
	Physical quantity	**Unit**
A	Force	$kg.m.s^{-1}$
B	Efficiency	J
C	Momentum	$N.s^{-1}$
D	Work	N.m

1.2 The graph shows how the velocity of an object changes with time.

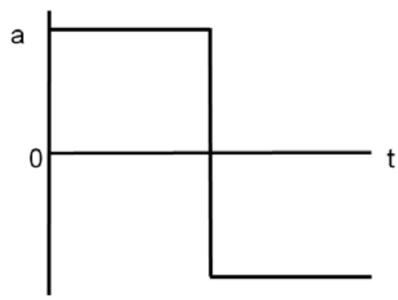


Which one of the following graphs correctly shows how the acceleration of the object changes with time?

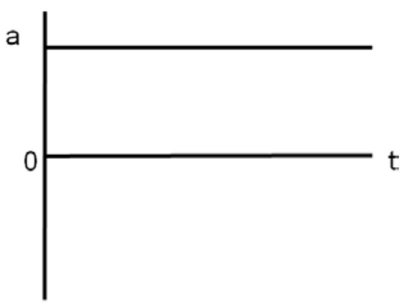
A



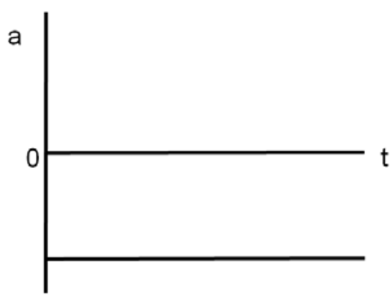
B



C



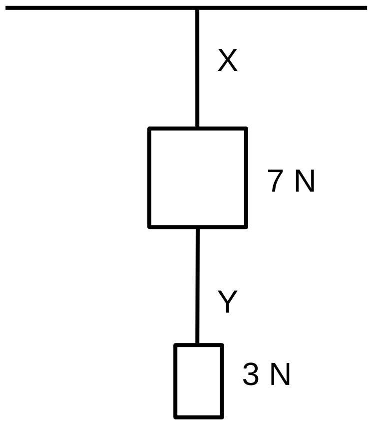
D



1.3 An object initially at rest travels a distance *d* in a time *t* at a constant acceleration. What is the time taken for the object to travel 16 *d* from rest at the same acceleration?

A 2 *t*
B 4 *t*
C 8 *t*
D 16 *t*

1.4 Two blocks of weight 7 N and 3 N are attached to two ropes, X and Y as shown below.



The blocks hang vertically at rest. The masses of the ropes are negligible. What is the tension in rope X and in rope Y?

	Tension in X	**Tension in Y**
A	10 N	10 N
B	10 N	3 N
C	7 N	4 N
D	7 N	7 N

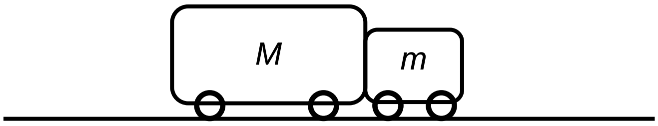
1.5 The mass of a rocket propelled car is approximately equal to the mass of the fuel in its tank. The rocket is ignited and the car is propelled in a straight line by a constant force. The effect of air resistance is negligible.

During a test run, fuel is used at a constant rate.

Which statement correctly describes the acceleration of the car during the test run?

A The acceleration of the car decreases as fuel is used
B The acceleration of the car remains constant as the fuel is used
C The acceleration of the car increases as fuel is used
D The acceleration of the car is zero and the car moves at a constant velocity

1.6 Two carts of different masses *m* and *M* are connected to each other at rest.



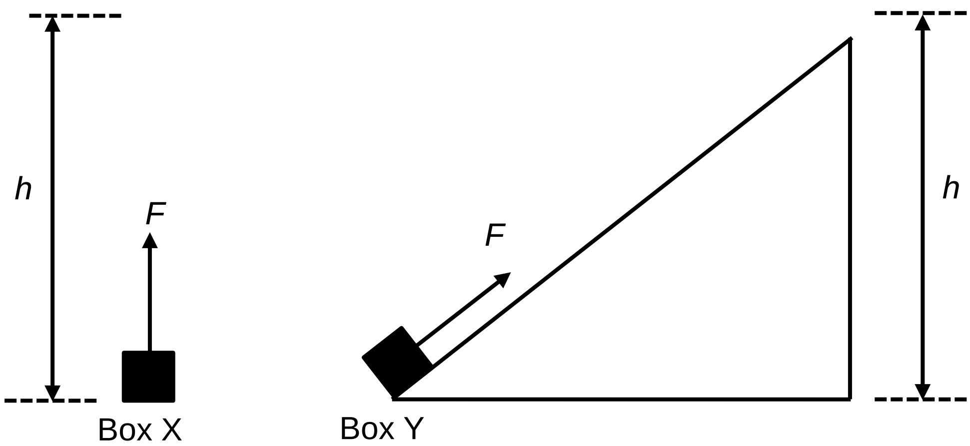
A small explosion causes the carts to move apart from each other. After the explosion, the cart of mass *m* moves with velocity *v*.

The change in momentum of mass *M* is

A – *mv*
B *mv*
C – *Mv*
D *Mv*

1.7 Two boxes X and Y have the same mass. Box X is lifted through a vertical height *h* by a force of magnitude *F*.

Box Y is pulled up a slope by a force of the same magnitude to reach the same vertical height, as shown.



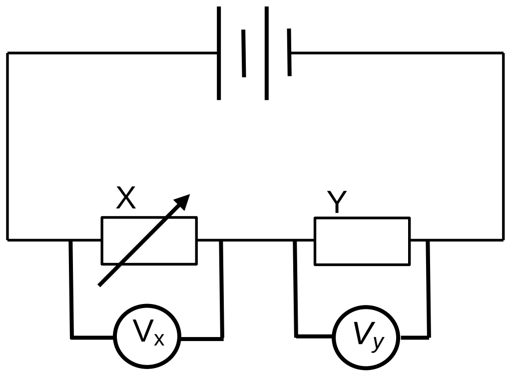
Which statement is correct?

	Change in gravitational potential energy of the boxes	**Amount of work done by *F***
A	Is the same for box X and box Y	Is the same on X and Y
B	Is the same for box X and box Y	Is more for box Y than for box X
C	Is less for box Y than for box X	Is less for box Y than for box X
D	Is more for box Y than for box X	Is more for box Y than for box X

1.8 The mass of a planet is twice that of the Earth. Its radius is half that of the radius of the Earth. The gravitational field at the surface of the Earth is *g*. The gravitational field at the surface of the planet is

A g
B $2g$
C $4g$
D $8g$

1.9 A battery with negligible internal resistance is connected to a variable resistor X and a fixed resistor Y as shown in the circuit diagram. The potential difference across variable resistor X is V_x and across resistor Y is V_y.

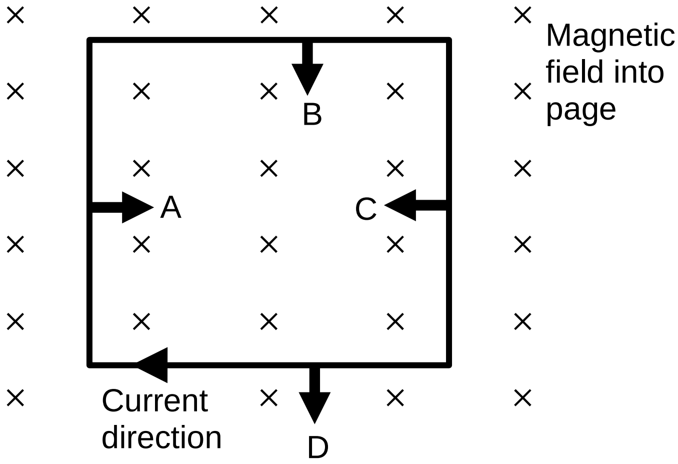


As the resistance of resistor X is increased, what happens to V_x and V_y?

	V_x	V_y
A	Decreases	Increases
B	Decreases	Stays the same
C	Increases	Decreases
D	Increases	Stays the same

1.10 A conducting square coil is placed in a uniform magnetic field. The magnetic field is directed into the page. There is a clockwise current in the coil.

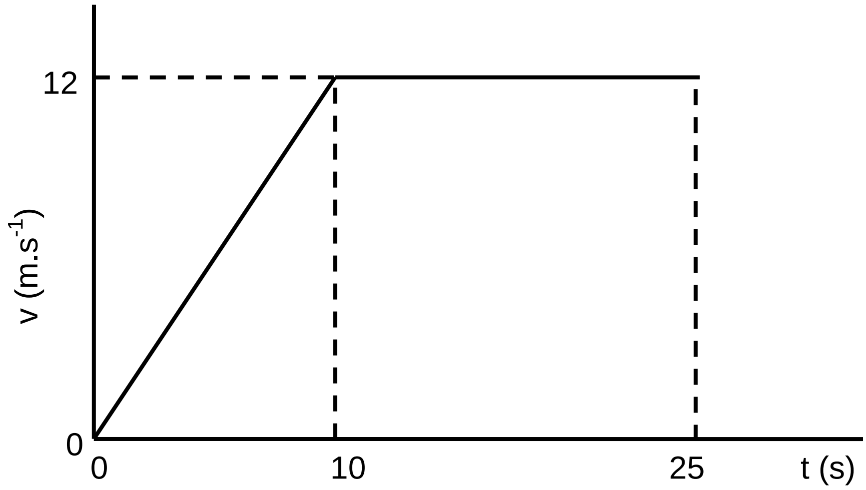
Which arrow indicates the correct direction of the force that acts on the side of the coil?



[20]

QUESTION 2 RACING

2.1 Tsholofelo runs **North** along a straight track. A velocity vs time graph of his motion is shown below.



2.1.1 Define *velocity*. (2)

2.1.2 Determine Tsholofelo's instantaneous velocity at 25 s. (2)

2.1.3 Calculate the magnitude of Tsholofelo's average velocity for 25 s. (6)

2.1.4 Define *acceleration*. (2)

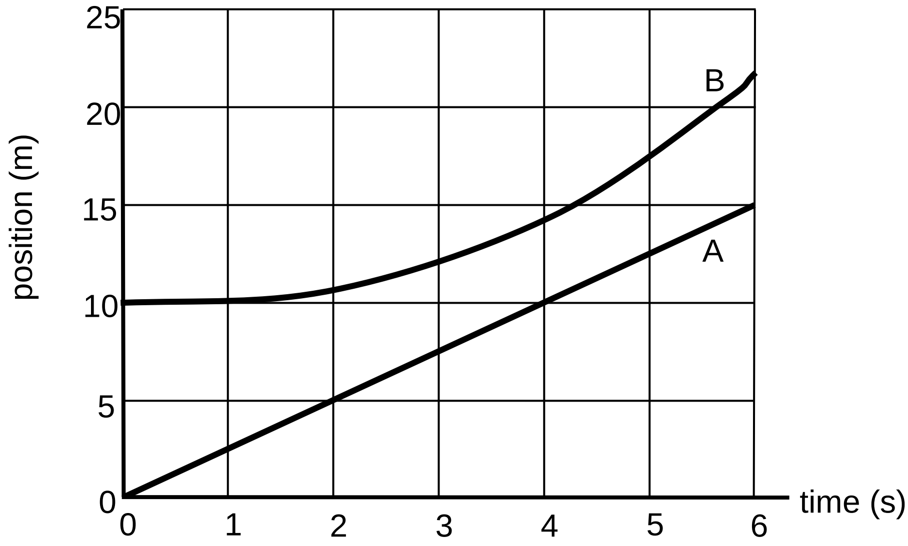
2.1.5 Calculate the magnitude of Tsholofelo's acceleration for the first 10 s of his run. (3)

2.2 Helen and Matthew are riding their scooters. Matthew is at rest when Helen passes him moving at a constant speed of 0,37 $m \cdot s^{-1}$ going in a straight line. After 1,8 s Matthew decides to chase Helen and try and catch her. Matthew accelerates at 0,91 $m \cdot s^{-2}$. How much time does Helen have from the moment she passed Matthew until Matthew is side by side with her? (7)

[22]

QUESTION 3 MOVING ALONG

3.1 The position vs time graph for objects A and B moving in a straight line in the same direction is shown below.



3.1.1 At the instant, t = 1 s, is the speed of object A greater than or less than the speed of object B? Use the graph to explain your answer. (3)

3.1.2 Do object A and object B ever reach the same speed? If so, at approximately what time are the speeds the same? (2)

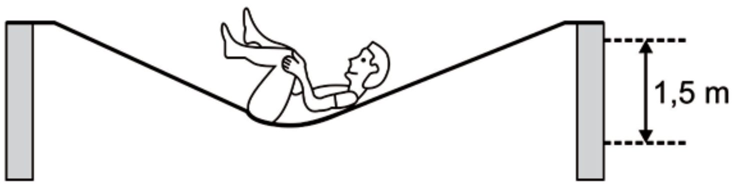
3.1.3 Which object has the greater displacement over the 6 s? (2)

3.2 A helicopter is flying vertically upwards at a constant speed of 2 $m \cdot s^{-1}$ when a stuntman steps out of an open door. The stuntman lands on a trampoline 4,32 s later.

3.2.1 Calculate the height of the helicopter above the trampoline as the stuntman jumped. (4)

3.2.2 Calculate the velocity of the stuntman when he reaches the trampoline. (5)

As the stuntman lands on the trampoline, the trampoline sags 1,5 m before launching the stuntman back into the air.



[Image available at: <https://boards.fireden.net/sci/thread/8833741>]

3.2.3 Draw a labelled free-body diagram of the stuntman when the sag is greatest. The relative sizes of the forces must be clear. (3)

3.2.4 At the very bottom, where the sag is greatest, is the stuntman's acceleration upward, downward or zero? Explain your answer. (2)

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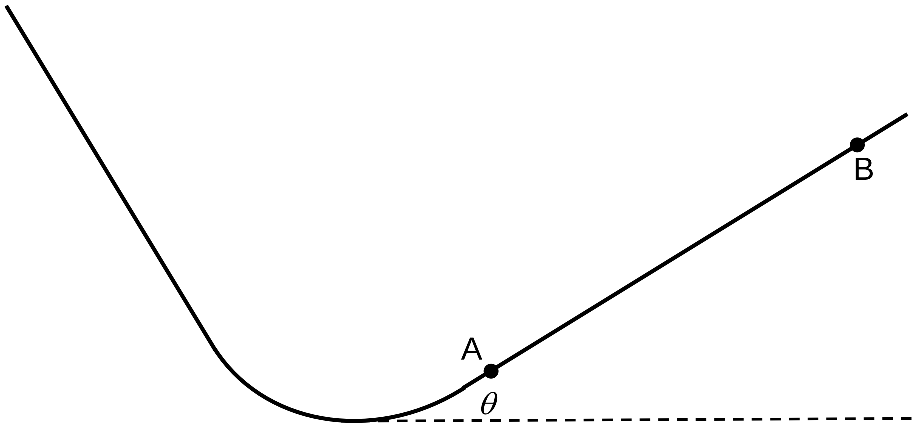
QUESTION 4 SLIDES AND ROCKETS

4.1 A child of mass 48 kg is on a water slide. The child slides down a steep slope and then travels up a gentle slope inclined at an angle θ to the horizontal. The coefficient of kinetic friction is 0,12.



The child passes point A with a speed of 15 $m \cdot s^{-1}$. The child just reaches point B.

4.1.1 Draw a labelled free-body diagram showing all the forces acting on the child while sliding **from A to B**. (3)

The component of the child's weight down the slope is 52,52 N.

4.1.2 Calculate the value of θ. (3)

4.1.3 Calculate the frictional force acting on the child. (4)

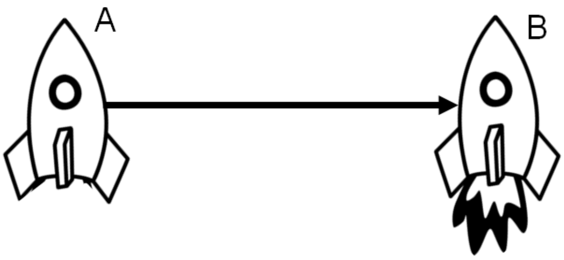
4.1.4 State *Newton's second law of motion*. (2)

4.1.5 Calculate the acceleration of the child. (4)

On reaching point B, the child immediately slides back down the slope towards point A.

4.1.6 Explain if the magnitude of the acceleration of the child from A to B is the same as, greater than or less than the magnitude of the child's acceleration from B to A. (3)

4.2 A rocket in deep space is moving sideways, with its rockets off, from A to B as shown in the diagram.



[Image from: <http://www.clker.com/clipart-black-and-white-rocket-fire.html>]

On reaching point B, the rocket fires its engines for 2 s while the rocket travels to some point C. At point C, the engines are turned off.

On the diagram **on the Answer Sheet**, draw in

4.2.1 point C and the path the rocket follows from B to C. (2)

4.2.2 the path the rocket follows from C onwards. (2)

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QUESTION 5 MODEL CARS AND CARTS

5.1 A student conducts an investigation to establish if the initial velocity of a model car determines the time taken for the car to stop when experiencing a constant resultant force. The student organises for model cars to start with different initial velocities (*v*). The car then brakes and the student measures the time taken for the car to stop (Δt) and tabulates the results.

5.1.1 State the **independent** variable in the investigation. (2)

The results that the student obtained is recorded in the table.

v (m·s^{-1})	Δt (s)
8	4,8
13	8,2
18	10,7
24	14,8
30	17,8
34	21,0

5.1.2 Plot a graph of time taken to stop, Δt (on the *y*-axis) vs initial velocity, *v* (on the *x*-axis) on the graph paper provided **on the Answer Sheet**. (6)

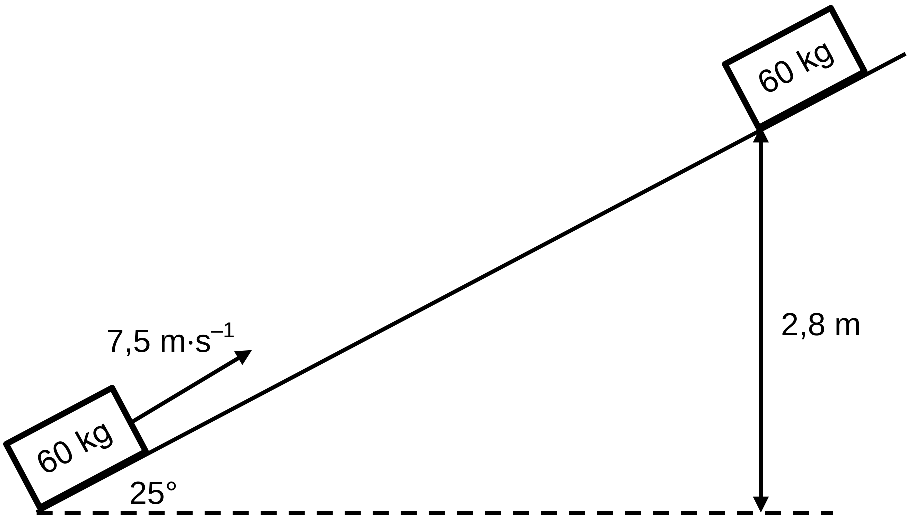
5.1.3 Calculate the gradient of your graph. Show the values you used on your graph and include the appropriate unit in your answer. (5)

5.1.4 Rearrange the equation $F_{net}\Delta t = m\Delta v$ to write Δt in terms of v for the experiment described. (1)

The resultant force experienced by the car was kept constant at –140 N for each velocity.

5.1.5 Hence, use your answers to Question 5.1.3 and Question 5.1.4 to calculate the mass of the model car. (3)

5.2 A cart with a mass of 60 kg is travelling at a speed of 7,5 m·s^{-1} at the bottom of a rough slope inclined at 25° to the horizontal. The cart comes to rest after travelling up the slope to a vertical height of 2,8 m.



5.2.1 Define *kinetic energy*. (2)

5.2.2 Calculate the kinetic energy of the cart at the bottom of the slope. (3)

5.2.3 Calculate the gain in gravitational potential energy of the cart at the highest point. (3)

5.2.4 Calculate the work done against the frictional force as the cart moves up the slope. (2)

5.2.5 Hence, calculate the magnitude of the frictional force acting on the cart as it moves up the slope. (4)

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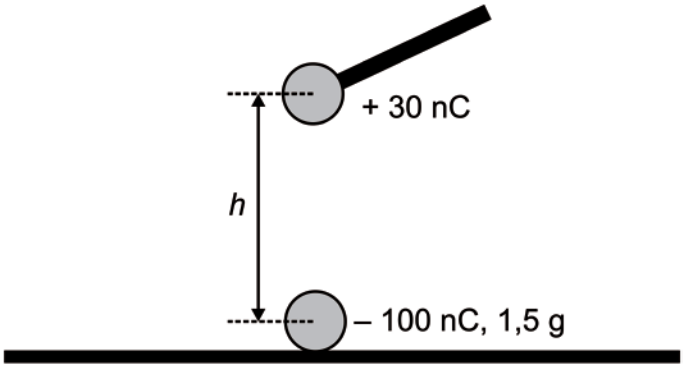
QUESTION 6 FIELDS

6.1 In a demonstration on electrostatics, a small metal ball on an insulating rod is given a charge of + 30 nC.

6.1.1 Draw a diagram showing the electric field around a + 30 nC charge. (2)

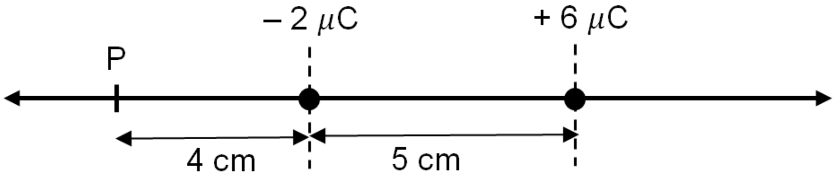
The + 30 nC charge is now held directly above a similar ball having a charge of – 100 nC and a mass of 1,5 g, which lies on an insulating table. The upper ball is brought closer to the lower ball in order to pick it up.



6.1.2 State *Coulomb's Law*. (2)

6.1.3 Calculate the distance *h* at which the 1,5 g ball will just be lifted off the table by the electrostatic force. (6)

6.2 Charged particles of – 2 μC and + 6 μC are placed 5 cm apart as shown in the diagram.



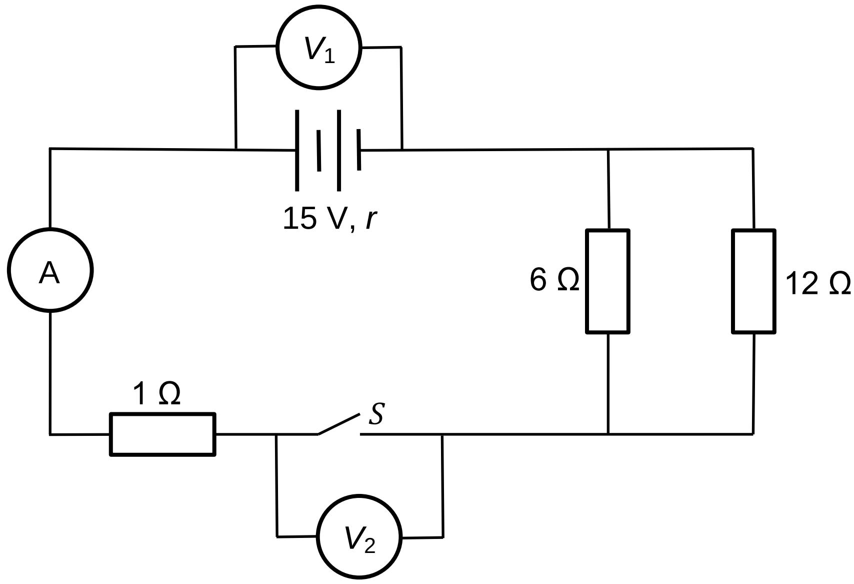
6.2.1 Calculate the magnitude of the electric field due to the + 6 μC charge at point P. (4)

6.2.2 Hence, calculate the net electric field at point P. (5)

[19]

QUESTION 7 ELECTRIC CIRCUITS

7.1 In the circuit represented below, the battery has an emf of 15 V and an unknown internal resistance. Voltmeter V_1 is connected across the battery and voltmeter V_2 is connected across an open switch *S*. The resistance of the ammeter is negligible.



The **switch *S* is open**.

7.1.1 Define *potential difference*. (2)

7.1.2 Determine the reading on voltmeter V_1. (2)

7.1.3 Determine the reading on voltmeter V_2. (2)

The **switch *S* is now closed**. The reading on voltmeter V_1 drops to 10,5 V.

7.1.4 Use a suitable equation to explain why the reading on V_1 drops. (3)

7.1.5 Calculate the effective resistance of the resistors in parallel. (3)

7.1.6 Calculate the reading on the ammeter. (3)

7.1.7 Calculate the internal resistance of the battery. (3)

7.2 An electrician needs to replace a bulb that has a 220 V supply. Unfortunately, the only working light bulb in stock is rated 50 V, 100 W.

7.2.1 Calculate the resistance of the 50 V, 100 W light bulb. (3)

7.2.2 Calculate the current that should flow through the working light bulb. (3)

The electrician uses the 50 V, 100 W light bulb and connects a resistor in series with the light bulb to ensure that the bulb operates at its correct rating when connected to the 220 V supply.

7.2.3 What should the resistance of the resistor be that the electrician connects in series with the light bulb? (3)

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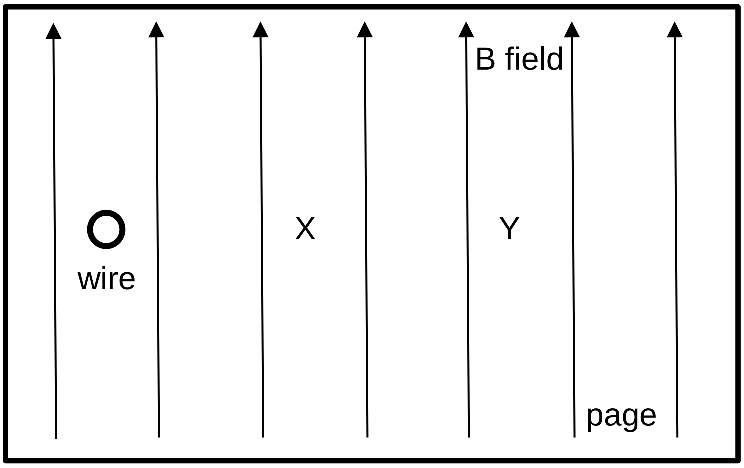
QUESTION 8 ELECTRODYNAMICS

8.1 A uniform magnetic field points upwards along the plane of the paper as shown in the diagram. A wire is perpendicular to the paper. When the wire carries a current, the net magnetic field at point X is zero.



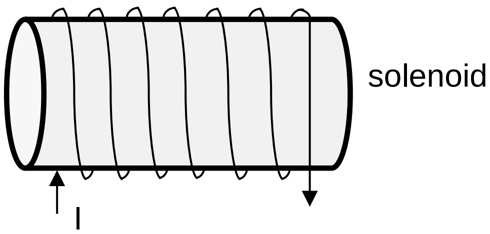
8.1.1 State the direction of the current in the wire (into or out of the page). (2)

Point Y is twice as far from the wire as point X. The magnetic field due to a current in a wire is inversely proportional to the distance from the wire.

8.1.2 Describe the net magnetic field at point Y. Be specific about the direction and magnitude relative to the uniform B field. (4)

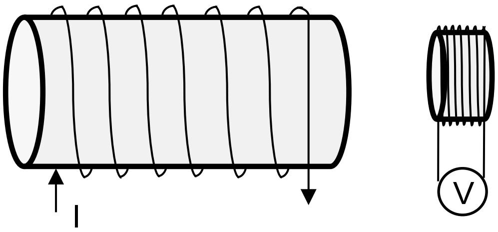
8.2 Name two practical examples of electromagnetic induction usage. (2)

8.3 The diagram below represents a solenoid, with a current of 2 A in the direction indicated.



8.3.1 On the diagram **on the Answer Sheet**, sketch the magnetic field associated with the solenoid **and** indicate which end is the north pole. (3)

A small coil at rest, connected to a sensitive voltmeter is situated near the stationary solenoid as shown.



8.3.2 State *Faraday's law of electromagnetic induction.* (2)

8.3.3 Explain why the voltmeter has a zero reading. (2)

8.3.4 State **three** different ways in which an emf could be induced in the small coil. (6)

[21]

PLEASE TURN OVER FOR QUESTION 9

QUESTION 9 PHOTONS AND ELECTRONS

The longest wavelength that will cause electrons to be ejected from a sodium metal surface when light is shone on the metal is 583 nm.

9.1 Define *threshold frequency*. (2)

9.2 Calculate the threshold frequency for sodium metal. (3)

9.3 Hence, calculate the work function of sodium metal. (3)

A low intensity light of wavelength of 450 nm is incident on the sodium.

9.4 Calculate the kinetic energy of the ejected electrons. (4)

A higher intensity light, also of wavelength 450 nm, replaces the low intensity light.

9.5 What will the effect be of the higher intensity light on

9.5.1 the kinetic energy of the ejected electrons? (2)

9.5.2 the number of ejected electrons? (2)

[16]

Total: 200 marks