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Physical Sciences Preliminary Examination

Paper I – Physics

Wednesday 11 September 2019

Form V

Marks: 200

Examiner: C Adelaar

Time: 3 hours

Examination number: _____

PLEASE READ THE FOLLOWING INSTRUCTIONS CAREFULLY

1. This question paper consists of 16 pages, a yellow answer sheet of 1 page (i) and a blue data sheet of 2 pages (i-ii). Please make sure that your question paper is complete.
2. Remove the data and answer sheets from inside this question paper. **Write your examination number on the answer sheet and question paper.**
3. **Please complete the multiple choice question on your answer sheet:**
There is only one correct answer for each of the multiple choice questions. The letter corresponding to the answer you think is correct should be marked with a cross, thus:

A	B	☒ C	D
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Here, C is the answer

4. Start each question on a new page, but please write on both sides of the paper.
5. Use the data and formulae whenever necessary.
6. Show all of the necessary steps in calculations.
7. Where appropriate, take your answers to 2 decimal places, unless instructed otherwise. Units need not be included in the working of calculations, but appropriate units should be shown in the answer.
8. It is in your own interest to write legibly and to present your work neatly. Please ensure that you number your answers as the questions are numbered.
9. When you hand in your exam, place the yellow answer sheet in the **front** of your answer book and your question paper booklet and green data sheet at the **back** of your answer book.

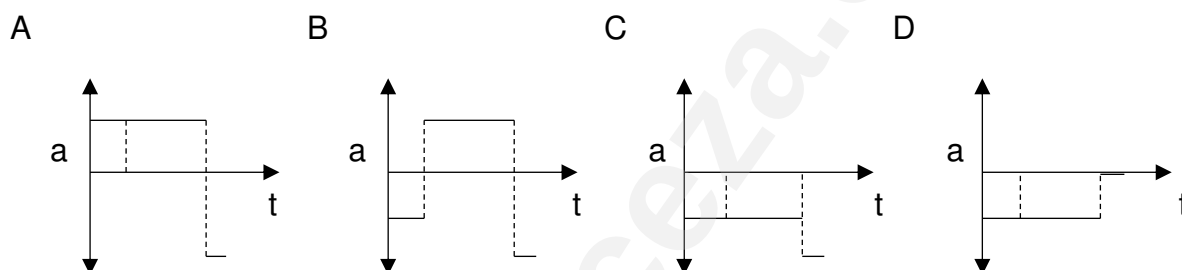
QUESTION 1 **MULTIPLE CHOICE** **Downloaded from eduresourceza.com**

Answer questions 1.1 – 1.10 on the grid provided on your **answer sheet**. Place a cross over the letter that represents the correct answer.

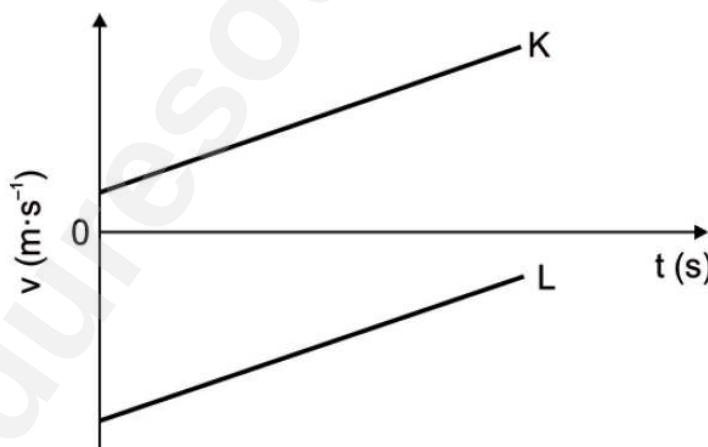
1.1 Which one of the following quantities is **not** a vector?

- A position
- B velocity
- C acceleration
- D distance

1.2 A ball is thrown upwards, reaches its maximum height and then falls down past the point of release and into a sandpit. Which one of the acceleration time graphs best represents this motion?



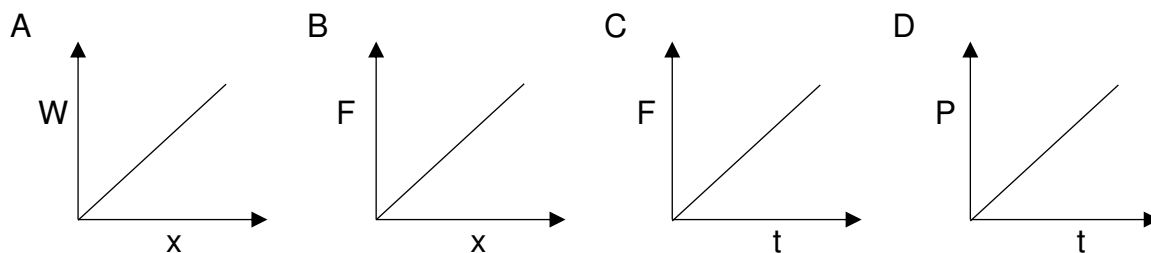
1.3 The velocity vs time graph shows the motion of two different objects sliding in a straight line across a horizontal surface.



Which one of the following options gives a reasonable explanation for the change in velocity for the object?

	Object	Explanation for change in velocity
A	K	Friction
B	K	Air resistance
C	L	Friction
D	L	Falling

- 1.4 For which one of the following graphs does the area under the graph **not** represent a physical quantity?



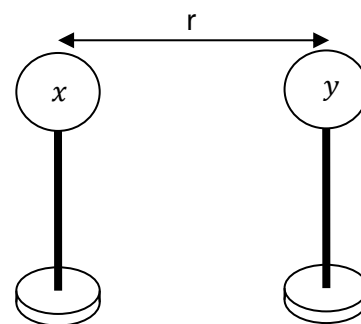
- 1.5 Two planets have identical masses, but different radii. The gravitational field on planet Y is a quarter of that on planet X.

Planet X has a radius, r , and a ball dropped from rest for 1 second has a kinetic energy, E .

What are the values of the radius of planet Y and the kinetic energy of a ball dropped from rest for 1 second on planet Y?

	Radius	Kinetic energy
A	$2r$	$E/4$
B	$2r$	$E/16$
C	$4r$	$E/4$
D	$4r$	$E/16$

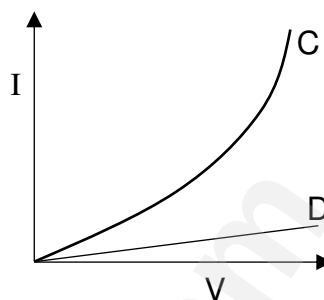
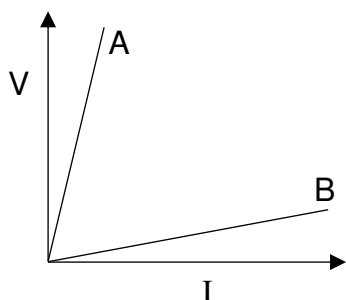
- 1.6 Two identical metal spheres on insulated stands placed a distance, r , from each other, carry different charges of x and y respectively, as indicated in the diagram. Both spheres experience a force, F .



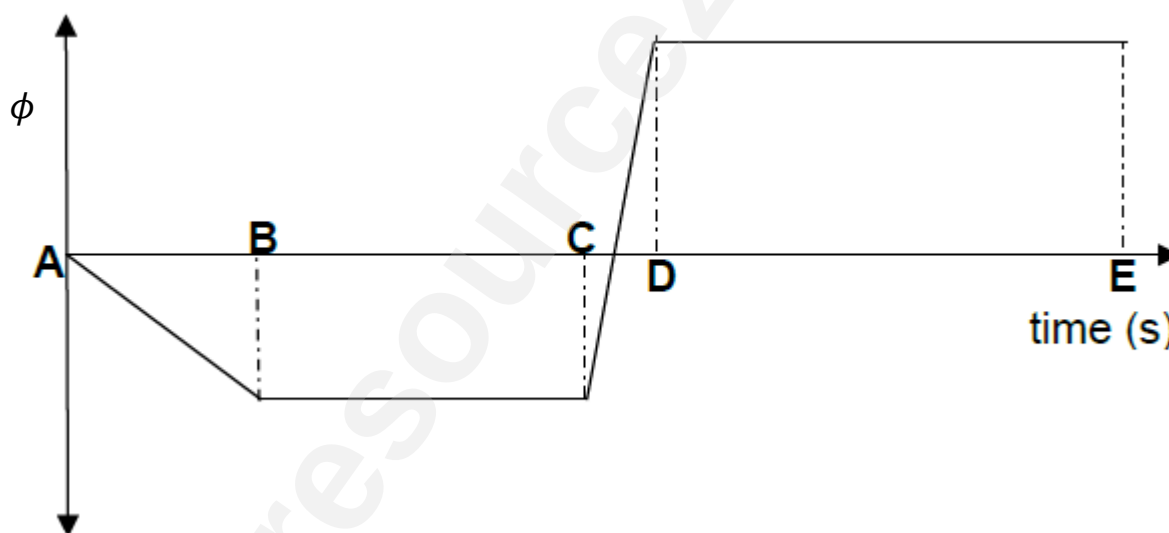
Which one of the following options does **not** give the strength of the electric field at the position of the charge stated?

	Electric field of ____ at position ____	Magnitude of the electric field
A	of x at position y	$\frac{kx}{r^2}$
B	of x at position y	$\frac{F}{y}$
C	of y at position x	$\frac{kx}{r^2}$
D	of y at position x	$\frac{F}{x}$

- 1.7 Which **one** of the following graph lines (A, B, C or D) is plotted from the results of an Ohm's law investigation where the resistor is **ohmic** and has the **least resistance**? Assume the scale on the axes of the same variable is the same across both graphs.



- 1.8 The magnetic flux (ϕ) through a loop of wire changes as shown in the sketch graph below. During which time interval will the induced emf be **positive and non-zero**?

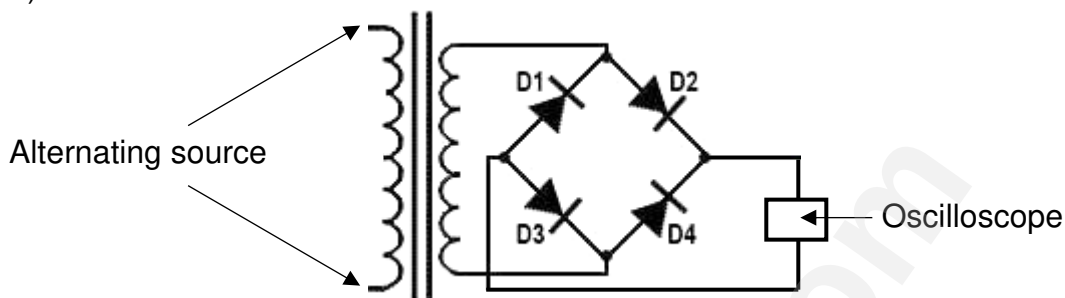


- A A-B
- B B-C
- C C-D
- D D-E

Questions 1.9 and 1.10 refer to the following information.

A transformer is connected to a diode bridge as shown in the diagram below. The input voltage to the primary coil is x V. The coil ratio of primary to secondary is 5:2.

The output voltage of the circuit is viewed on an oscilloscope (a device that creates a graph of the circuit output).



- 1.9 Which option below correctly identifies the type of transformer shown and the output voltage of the secondary coil?

	Type of transformer	Output voltage of the secondary coil (V)
A	Step up	$\frac{2x}{5}$
B	Step up	$\frac{5x}{2}$
C	Step down	$\frac{2x}{5}$
D	Step down	$\frac{5x}{2}$

- 1.10 Which one of the following options gives the correct graphed output on the oscilloscope screen and the correct path of current through the diode bridge for one full cycle?

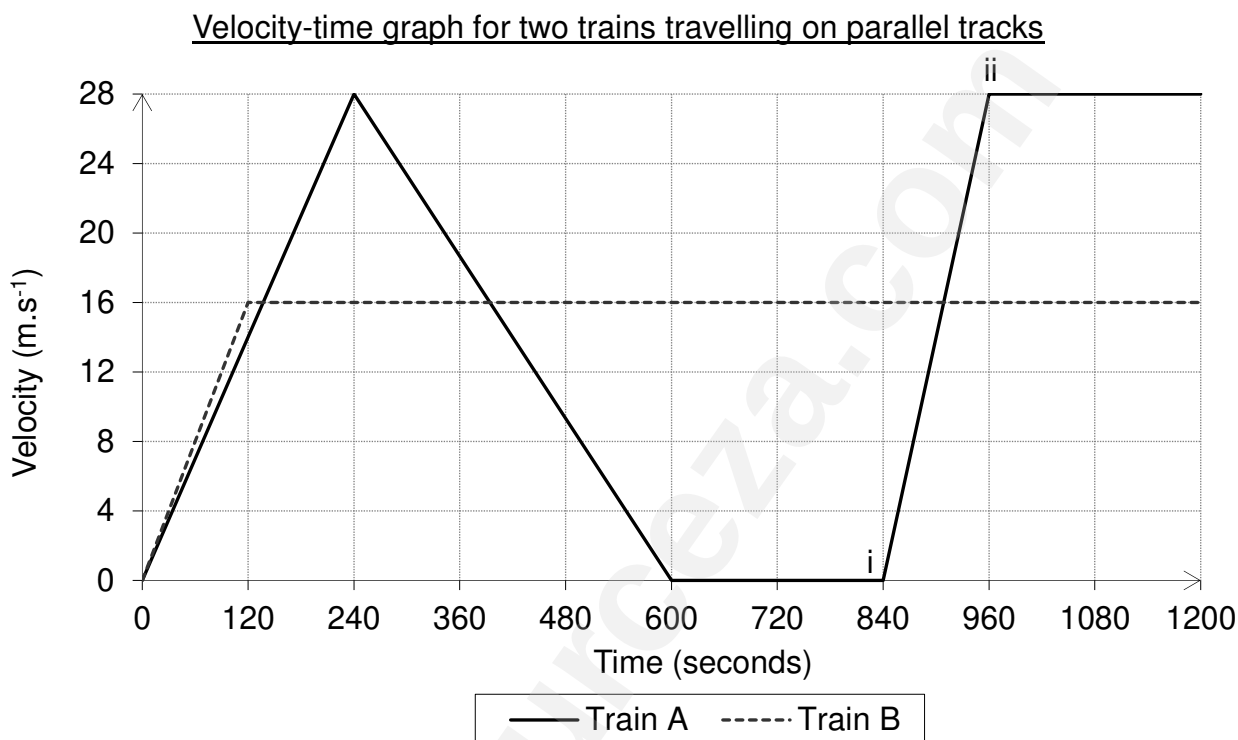
	Oscilloscope output	Possible path through diode bridge for one full cycle
A		Coil → D2 → Oscilloscope → D3 → Coil Coil → D4 → Oscilloscope → D1 → Coil
B		Coil → D2 → Oscilloscope → D3 → Coil
C		Coil → D4 → Oscilloscope → D3 → Coil Coil → D2 → Oscilloscope → D1 → Coil
D		Coil → D2 → Oscilloscope → D3 → Coil Coil → D4 → Oscilloscope → D1 → Coil

QUESTION 2

TRAINS

- 2.1 Two trains, start at the same point, and travel in a southerly direction on different but parallel tracks.

The velocity-time graph shows the motion of the two trains as they approach a station and then move on from the station.



- 2.1.1 Define *acceleration*. (2)
- 2.1.2 Which train experiences the greatest acceleration at any point in time? (1)
- 2.1.3 Calculate the acceleration of Train A between points i and ii. (4)
- 2.1.4 At the time that Train A reaches and stops at the station (at $t = 600$ s), is it ahead of or behind Train B, and what is the distance between the two trains? (6)
- 2.1.5 The output power of the locomotive engine for Train B is 2000 kW when travelling at 16 m.s^{-1} as shown from 120 s onwards. Calculate the kinetic friction of the train in this situation. (4)
- 2.1.6 At 1200 s, Train B starts to slow down at a rate of $0,05 \text{ m.s}^{-2}$, eventually coming to rest. What distance does the train cover during this period of slowing to a stop? (4)

2.2 A child sitting on the smooth floor of Train B while it travels at constant velocity south, rolls a ball in an easterly direction directly across the very smooth floor of the carriage. The ball covers a distance of 2,8 m in 2,5 seconds at constant velocity.

2.2.1 Calculate the magnitude of the average velocity of the ball relative to the floor of the train. (3)

2.2.2 Define *resultant vector*. (2)

2.2.3 Calculate the resultant velocity of the ball. Include a labelled vector diagram in your answer. (6)

2.2.4 If it were possible, in which direction should a ball be rolled across the train carriage in order to ensure that its velocity relative to the ground is easterly? Write down only the letter of your choice. (2)

A



B



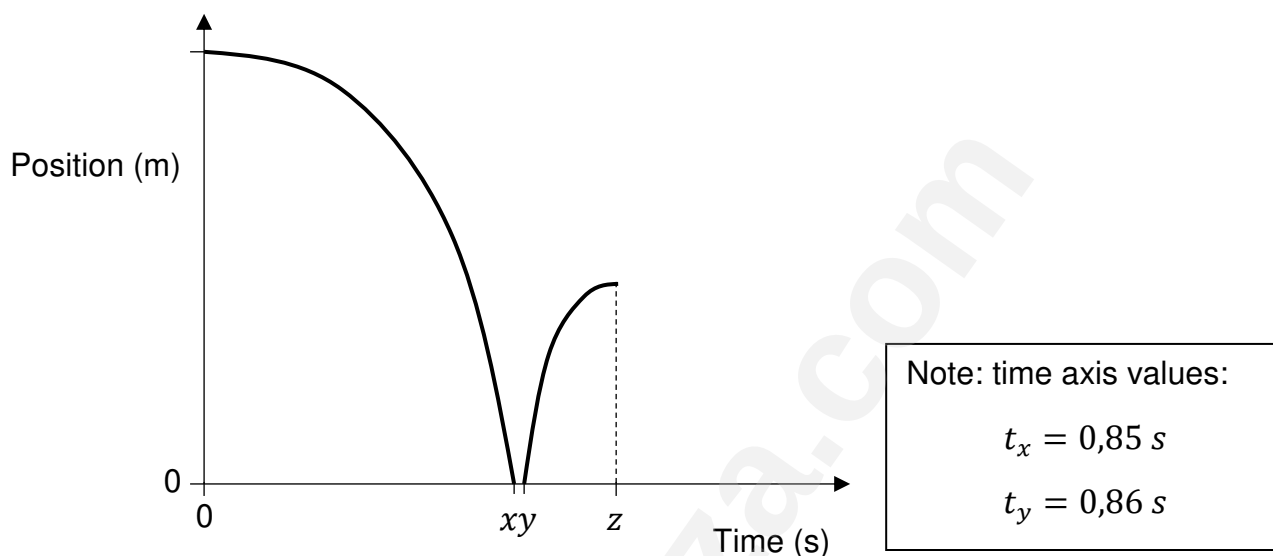
C



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QUESTION 3

The following position vs time graph shows the motion of a 58 g ball which is dropped from a certain height and then which bounces on the floor and rebounds to a different height where it stops momentarily. The graph is not drawn to scale. Assume that air resistance is negligible.



- 3.1 Define *displacement*. (1)
- 3.2 According to the graph, which direction is taken to be positive? (1)
- 3.3 Calculate the height from which the ball was initially dropped. (4)
- 3.4 Calculate the magnitude of the velocity with which the ball hits the ground. (4)

The impulse of the ground on the ball is 0,61 N.s.

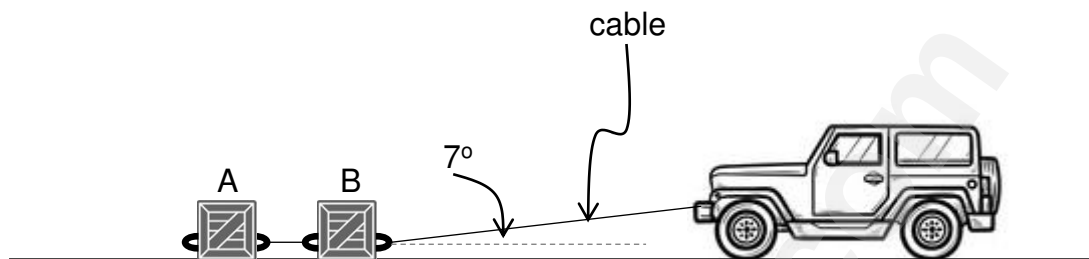
- 3.5 Define *impulse*. (2)
- 3.6 Calculate the rebound velocity of the ball. (4)
- 3.7 Determine the value of time z when the ball reaches its maximum height after the bounce. (4)
- 3.8 Calculate the force that the floor exerts on the ball. (5)

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QUESTION 4 **CABLES, SLIDING AND FRICTION**

A Jeep uses a cable attached to the vehicle to drag two heavy wooden crates across a concrete surface to the right. The Jeep reverses and as a result, a force of 1300 N is exerted on crate B by the cable at an angle of 7° to the horizontal. The Jeep and the crates accelerate to the right.

Crates A and B each have a mass of 100 kg and they are identical in all respects.



Crate A experiences a kinetic frictional force of 607,6 N. While crate B is identical to crate A and has the same mass, it experiences a lesser kinetic frictional force during the motion.

- 4.1 Define *normal force*. (2)
- 4.2 Use a suitable equation to help you explain why crate B experiences a lesser kinetic frictional force than crate A, despite being identical to crate A. (3)
- 4.3 Calculate the co-efficient of kinetic friction for the concrete surface. (3)
- 4.4 Calculate the kinetic friction experienced by crate B. (4)
- 4.5 Draw a labelled free body diagram for crate B. (5)
- 4.6 Determine the acceleration of the crates. (5)
- 4.7 Hence, calculate the magnitude of the tension in the cable between the two crates. (3)
- 4.8 Calculate the work done by the cable in the horizontal direction to move the crates a distance of 8 m along the horizontal concrete surface. (3)

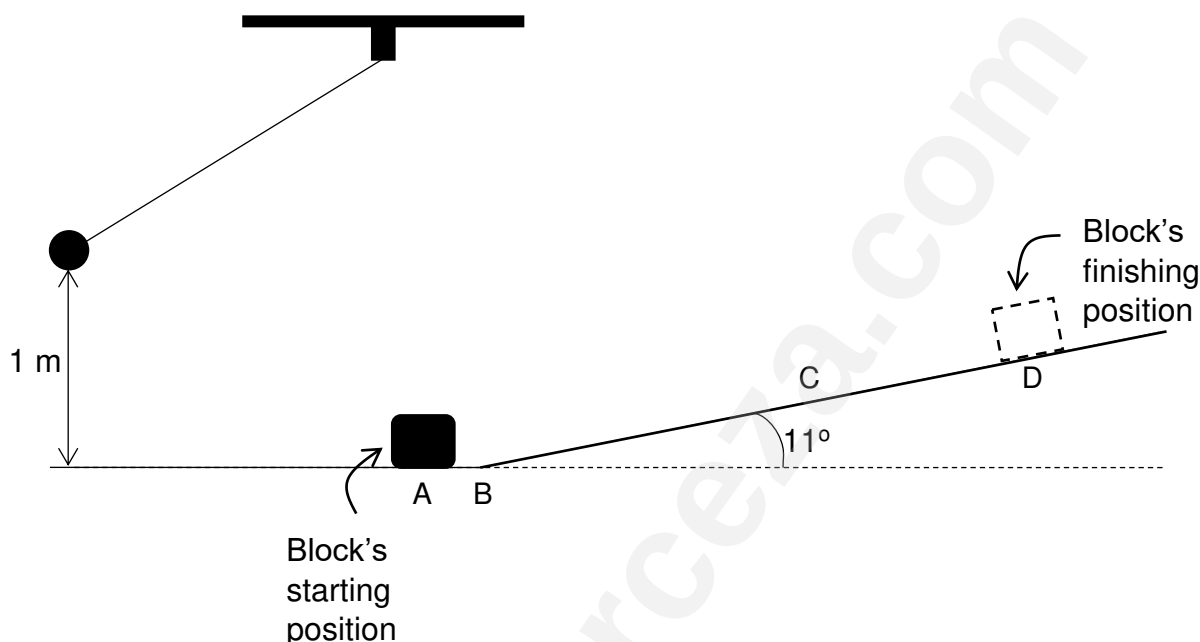
[28]

QUESTION 5

PENDULUM AND INCLINED PLANE

A pendulum of mass 1 kg is lifted to a height of 1 m and released from rest. It swings down, and at its lowest point, it collides with a 0,5 kg block which is stationary on a horizontal frictionless surface at A.

As a result of the collision, the block moves off and then at B, it starts to travel up a rough inclined surface as shown. The block eventually comes to rest on the inclined surface at D, having moved a distance of 2,1 m along the sloped surface from B, past C to D.



- 5.1 State *the principle of conservation of mechanical energy*. (2)
- 5.2 Calculate the magnitude of the pendulum's velocity as it strikes the block. (3)
- 5.3 At the instant of the strike, compare the force of the pendulum on the block, to the force of the block on the pendulum. State the law that you used to give your answer. (3)

The pendulum's velocity is reduced to $0,8 \text{ m.s}^{-1}$ after the collision with the block.

- 5.4 State *the law of conservation of linear momentum*. (2)
- 5.5 Calculate the velocity of the block immediately after the collision with the pendulum. (4)
- 5.6 State *the work-energy theorem*. (2)
- 5.7 Draw a labelled free body diagram of all of the forces acting on the block **along the inclined surface** at position C. (2)
- 5.8 Calculate the magnitude of the frictional force acting on the block helping to bring it to rest on the slope. (6)

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QUESTION 6

- 6.1 Two point charges Q_A and Q_B are placed and fixed a certain distance apart. A third charge q is placed between them along a straight line. The distance between Q_A and q is one third of the distance between Q_B and q as shown in the diagram below (which is not drawn to scale).

The magnitude of Q_A is $+60 \mu\text{C}$.



- 6.1.1 Draw the electric field around point charge, Q_A . (2)

There is no net electric field at the position where charge q is placed.

- 6.1.2 Considering the statement directly above, what is the sign of charge, Q_B ? (1)

- 6.1.3 Use a labelled vector diagram of electric fields to illustrate what is meant by the statement: "There is no net electric field at the position where charge q is placed." (3)

- 6.1.4 State *Coulomb's law*. (3)

- 6.1.5 Determine the magnitude of the charge, Q_B . Give your answer in SI units. (5)

- 6.2 Two identical conducting spheres of unknown mass are suspended from insulating threads. The spheres are charged with very small charges of $+1,1 \times 10^{-11} \text{ C}$ and $+1,69 \times 10^{-10} \text{ C}$. They are placed 0,15 m apart.

Calculate the mass of each sphere if the electrostatic force of repulsion is to be exactly matched by the gravitational force of attraction between them. (4)

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Jack and Jabu want to build a simple contact alarm with both a light and a buzzer. They do some research into the components that would work best and they find the following information on each component.

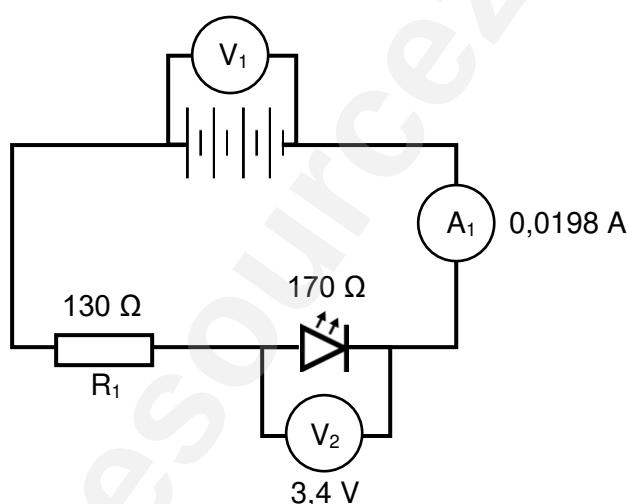
Blue LED Light

Symbol: 

Operation:

- Resistance of LED = $170\ \Omega$
- Must be connected in series with a $130\ \Omega$ resistor (R_1) to limit the current passing through the LED
- Suggested supply voltage: 4 x AA alkaline cells each with an emf of 1,5 V

Sample circuit:



When connected as shown, the reading on A_1 is 0,0198 A.

- 7.1 Refer to the **LED information** and calculate the reading on the voltmeter (V_1). (3)
- 7.2 Determine the internal resistance of **each** cell. Give your answer to 2 decimal places. (4)
- 7.3 According to the sample circuit setup above, how much energy is dissipated by the LED when it shines for 10 seconds? (4)

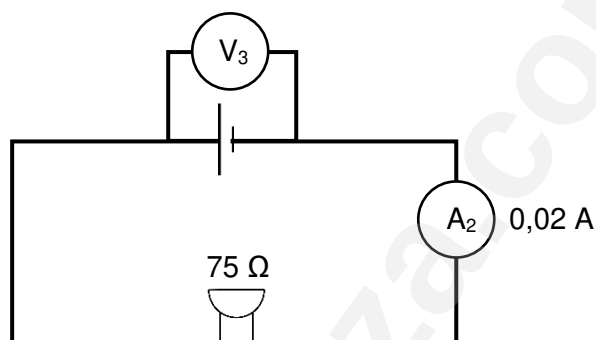
Buzzer

Symbol: 

Operation:

- Resistance of buzzer = $75\ \Omega$
- Wide tolerance for voltage and current supply
- Use with AA alkaline cell/s with an emf of 1,5 V

Sample circuit:



Refer to the **buzzer** sample circuit. Jabu now investigates how the reading on the ammeter changes as he puts more cells (connected in series) into the circuit.

7.4 Give the full name for the:

7.4.1 independent variable in this investigation.

7.4.2 dependent variable in this investigation. (3)

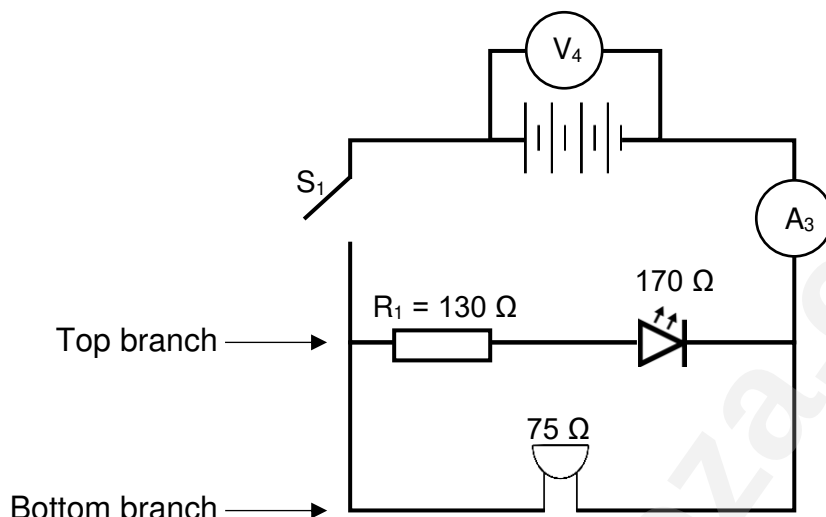
7.5 Name the type of relationship that you would expect to find between these two variables (in question 7.4 above). (1)

7.6 List one other variable other than the resistance of the buzzer that must be fixed in order for this to be a fair investigation. You may not refer to apparatus in your answer. (1)

Jack and Jabu decide on the circuit design shown below for their alarm which incorporates both the LED and buzzer connected in parallel as shown below. The resistance of each component remains unchanged by the new arrangement.

In this circuit, Jack and Jabu use four new AA cells **each** with an emf of 1,5 V and an internal resistance of 0,15 Ω .

Combined circuit:



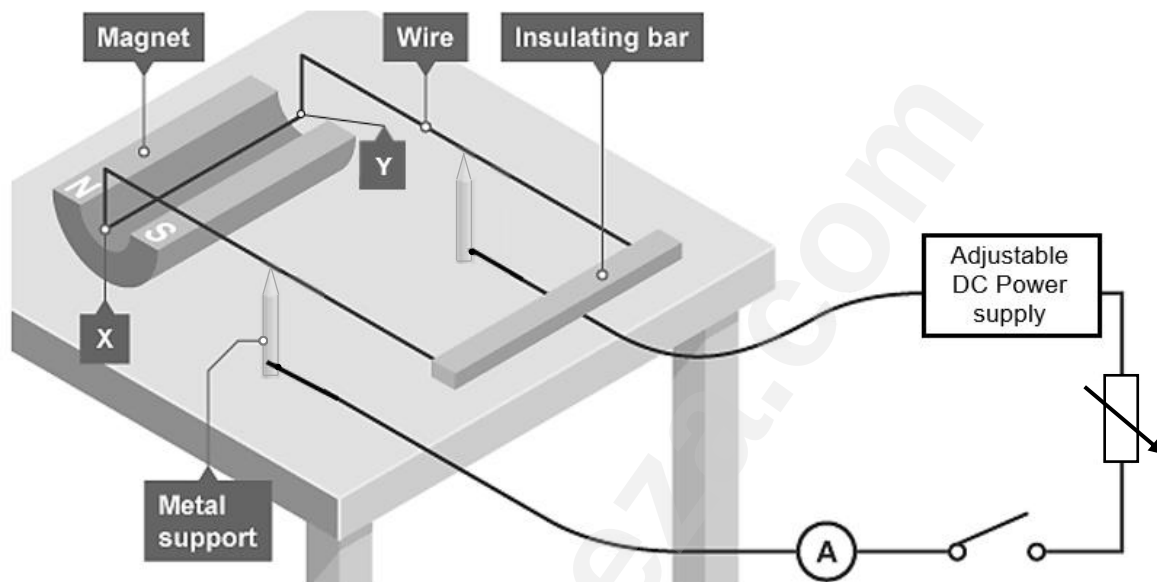
Refer to the combined circuit above and answer the following questions.

- 7.7 Determine the reading on ammeter, A_3 . (6)
- 7.8 Calculate the ratio of the current in the top branch to the current in the bottom branch of the circuit, $\frac{I_{top}}{I_{bottom}}$. (2)
- 7.9 Calculate the power output of the battery for the combined circuit. (4)
- 7.10 When the circuit is switched on the buzzer overheats and stops working. How will the reading on the voltmeter, V_4 , be affected when the buzzer stops working? Answer with increases / decreases / remains the same. Use a suitable equation to help you explain your answer. (4)

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QUESTION 8

- 8.1 The picture below shows a piece of apparatus called a current balance. A 15 cm length of conducting wire (XY) runs through a magnetic field set up inside a permanent magnet. The total length of wire used in the circuit is 1,2 m. All wires and metal supports conduct electricity. The insulating bar does not conduct electricity.

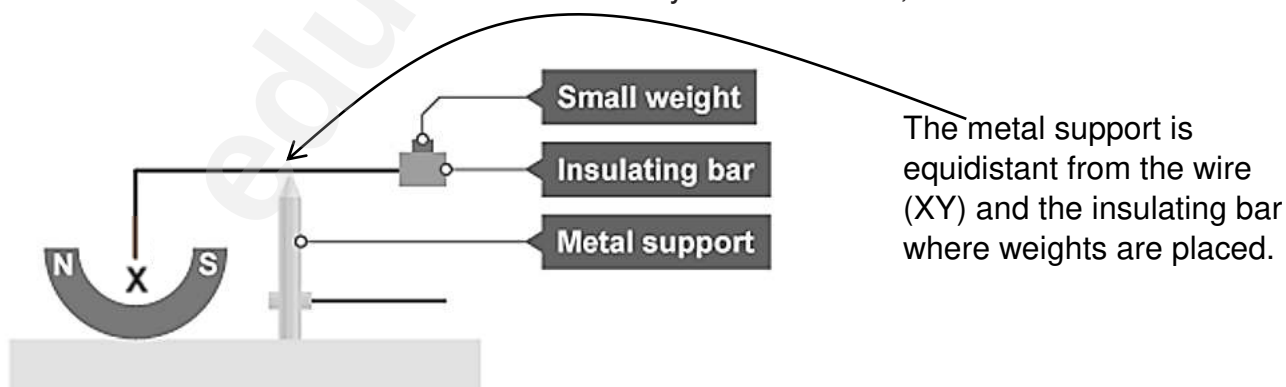


- 8.1.1 **On the answer sheet** provided, the view from above the magnet is shown with wire, XY running between the poles.

On the diagram, sketch lines to show the direction of the magnetic field due to the permanent magnet. (2)

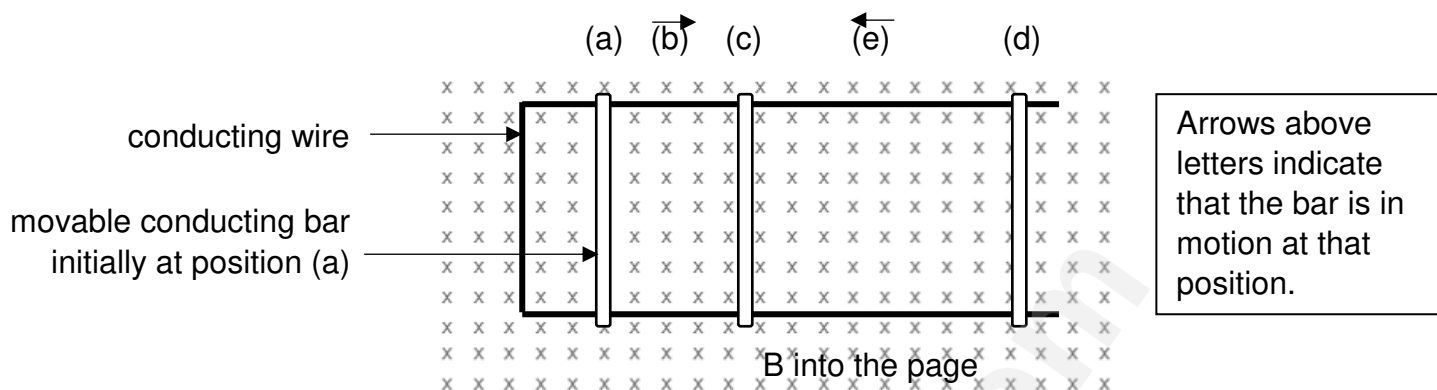
- 8.1.2 When the switch is closed, the part of the wire labelled XY experiences a force and moves downwards. Is the current direction from X to Y or Y to X? (1)

The picture below shows how a small weight (of known mass) can be placed on the insulating bar. The view is from the X end of the wire and the system as shown, is balanced.



- 8.1.3 Use both pictures as well as suitable equations to describe briefly how the current balance could be **used** to determine the magnitude of magnetic flux density, B , set up by the magnet. Include reference to the numerical value of any relevant known quantities. Please answer in point form. (5)

- 8.2 A U-shaped piece of conducting wire is placed in a uniform magnetic field directed into the page. A single movable conducting bar is positioned in electrical contact with the arms of the wire as shown, thus creating a loop of conducting wire. There is no supplied emf.



- The bar starts at position (a) and remains stationary for t seconds.
- The bar is moved right at a constant velocity, v , for a further t seconds, passing position (b) and reaching position (c).
- The bar is then moved right at a constant velocity, $2v$, for a further t seconds, reaching position (d).
- The bar is then immediately moved left so that it returns to position (c) at a constant velocity, $2v$, in t seconds passing position (e) moving left.

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

8.2.2 During the motion described:

- At what positions (a), (b), (c) or (e) is a current induced in the loop? (2)
- If there is a current induced in the loop (question 8.2.2(a) above), state the direction of the induced current as clockwise or anti-clockwise for each position. (2)
- Name the law that predicts the direction of the induced current. (1)

8.2.3 For position (b) briefly explain why there is, or why there is not, an induced current in the loop. Use suitable equations in your explanation. (3)

8.2.4 In which position, (a), (b), (c) or (e) will the magnitude of the induced emf be the greatest? (1)

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TOTAL MARKS: 200

Sources: Acknowledgements and Thanks:

Question 1: 1.3 adapted from the IEB Grade 12 Final NSC Physics Examination 2018

Question 1: 1.6 image from the DoE Grade 12 Physics Exemplar 2008

Question 1: 1.8 from the IEB Grade 12 Supplementary NSC Physics Examination 2019

Question 1: 1.9 and 1.10 Images adapted from <http://www.learnabout-electronics.org/PSU/psu11.php> and https://en.wikipedia.org/wiki/Pulsed_DC#/media/File:Rectification.svg

Question 4: Jeep image from <https://www.storyblocks.com/stock-image/jeep-hand-drawn-outline-doodle-icon-bkx9otxktqjmjb0ya>, crate image from <https://www.vecteezy.com/vector-art/98207-box-and-crate-vector>

Question 8: Images in 8.1 adapted from <https://www.bbc.com/bitesize/guides/z57y66f/revision/4>