



NATIONAL SENIOR CERTIFICATE EXAMINATION
EXEMPLAR PAPER 2014

PHYSICAL SCIENCES: PAPER I

Time: 3 hours

200 marks

PLEASE READ THE FOLLOWING INSTRUCTIONS CAREFULLY

1. This question paper consists of 15 pages and an Answer Sheet of 1 page. Please make sure 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. Show your working in all calculations.
 7. Units need not be included in the working of calculations, but appropriate units should be shown in the answer.
 8. Where appropriate express answers to TWO decimal places.
 9. It is in your own interest to write legibly and present your work neatly.
-

QUESTION 1 MULTIPLE CHOICE

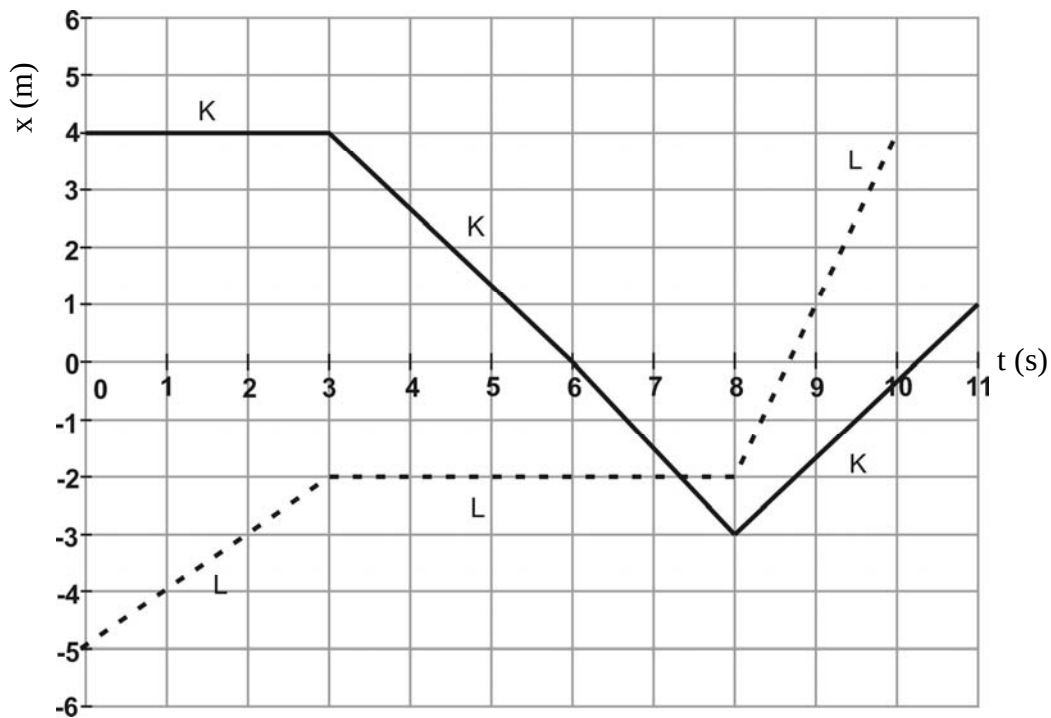
Select the answer which you consider to be the most correct.

- 1.1 Two forces act on an object. A large force acts due south on the object while a smaller force acts due east. What is the direction of the resultant force acting on the object?

A due south
B at 45° between south and east
C between south and east, but closer to east than south
D between south and east, but closer to south than east

(2)

- 1.2 The graph shows the position (x) of two soccer players, K and L, moving along the same horizontal straight line.

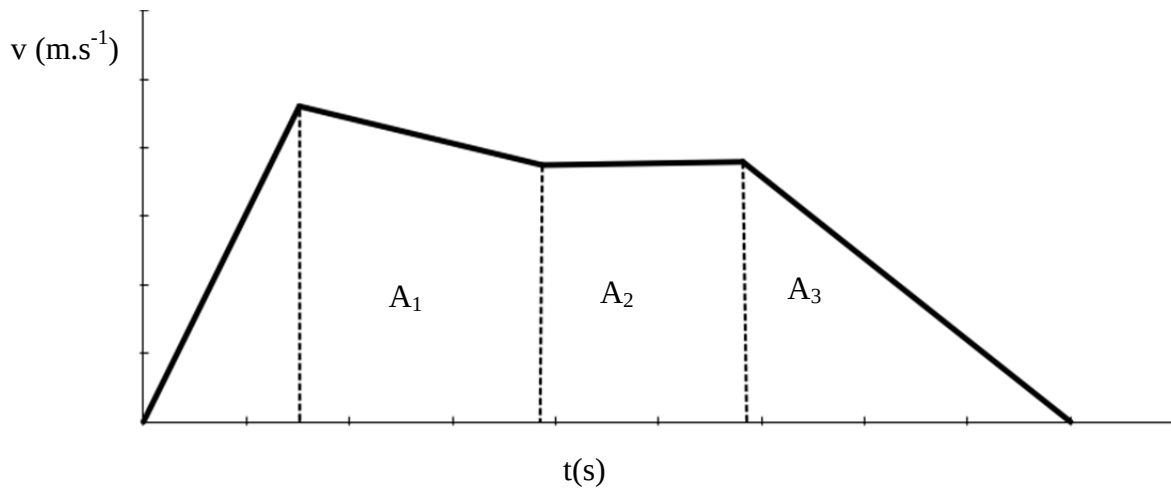


At $t = 3$ s, what is the distance between K and L?

A -2 m
B 2 m
C 4 m
D 6 m

(2)

- 1.3 The motion of a car moving along a straight road is shown in the speed-time graph below.



Which area represents the total distance moved by the car during the time its speed is decreasing?

- A A_1
- B A_3
- C $A_1 + A_3$
- D $A_1 + A_2 + A_3$

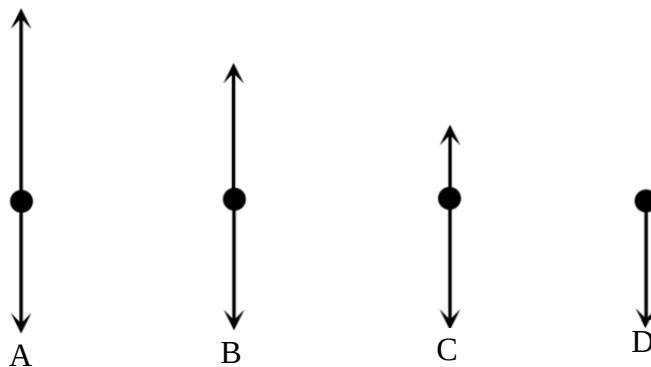
(2)

- 1.4 Curiosity, NASA's explorer landed on Mars. During the final descent, small rockets were fired to slow Curiosity for landing.



[<http://www.bbc.co.uk/news/science-environment-18933037>]

Which free-body diagram correctly represents the vertical forces acting on Curiosity during its final descent?



(2)

- 1.5 Two charged particles, X and Y exert repulsive forces on each other. The charge on X is $+4q$ while the charge on Y is $+q$.

The magnitude of the force on particle Y is

- A four times as big as the force on X.
- B twice as big as the force on X.
- C the same size as the force on X.
- D one quarter as big as the force on X.

(2)

- 1.6 A 50 g bouncing ball and a 50 g lump of clay are thrown at a wall with equal speeds. The clay sticks to the wall and the bouncing ball bounces back. Which substance exerts a larger impulse on the wall?

- A Neither exerts an impulse on the wall, as the wall does not move.
- B They exert equal impulses as they have equal momentum.
- C The clay lump exerts a larger impulse as it sticks.
- D The bouncing ball exerts a larger impulse as it bounces.

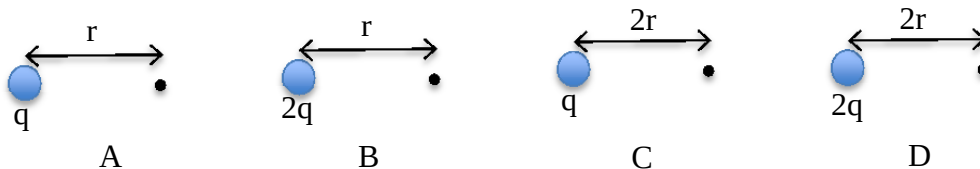
(2)

- 1.7 The work done by a net force on an object is always equal to that object's change in

- A total energy
- B mechanical energy
- C potential energy
- D kinetic energy

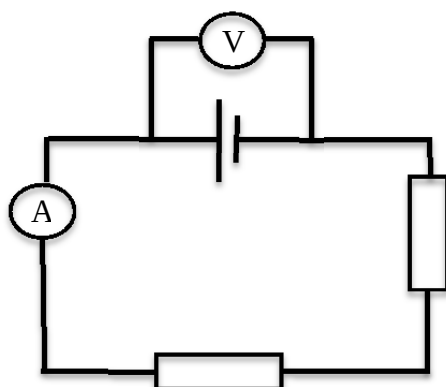
(2)

- 1.8 The following diagrams illustrate the size of the charge on a particle and the distance away from the charged particle. In which diagram will the electric field be the largest at the point indicated?



(2)

- 1.9 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.

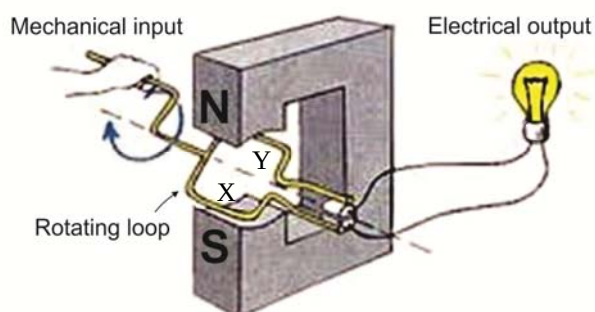


What happens to the readings on the ammeter and voltmeter when a third resistor is added in series with the other two resistors?

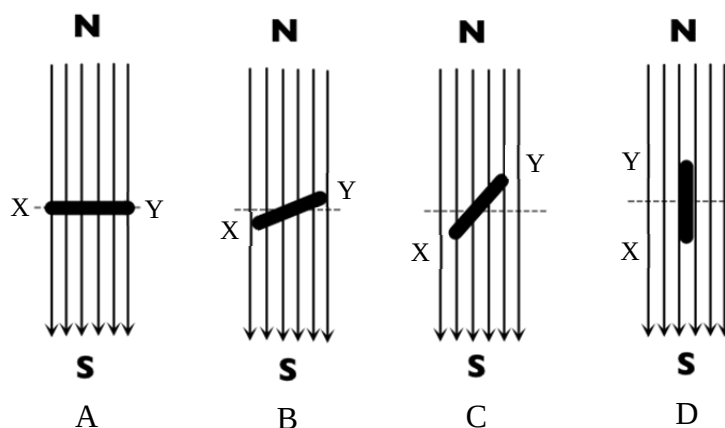
	Ammeter reading	Voltmeter reading
A	Increases	Increases
B	Decreases	Stays the same
C	Decreases	Increases
D	Stays the same	Decreases

(2)

- 1.10 In a generator, a loop of wire is rotated in a magnetic field to cause the light to glow.



The solid dark line in the following diagrams illustrates the orientation of the **plane XY** of the loop. For which of the diagrams below will the **emf induced** in the coil be zero?

(2)
[20]

QUESTION 2 MOVING ALONG

- 2.1 A cyclist (Paul) has a velocity of 20 m.s^{-1} east and a constant acceleration of 4 m.s^{-2} west. Another cyclist (Peter) has a velocity of 20 m.s^{-1} east and a constant acceleration of 4 m.s^{-2} east.

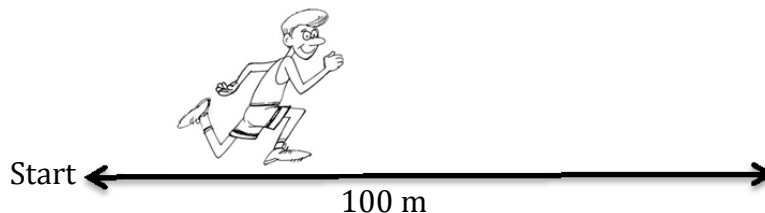
2.1.1 After 1 s calculate the magnitude of the velocity of

(a) Paul

(b) Peter (5)

2.1.2 Explain why Peter and Paul have such different velocities after 1 s even though they both experienced an acceleration of 4 m.s^{-2} . (2)

- 2.2 An athlete is training to compete in a 100 m event. As part of his training, the coach makes him run 100 m along the track, turn around and run back to the start.



The athlete takes 3 s to accelerate uniformly from rest to a maximum velocity of $9,6 \text{ m.s}^{-1}$. The athlete keeps running at $9,6 \text{ m.s}^{-1}$ for 7,5 s then slows uniformly to stop at the 100 m mark. He immediately jogs back to the start taking 25 s to return.

2.2.1 Calculate the magnitude of his acceleration at the start of the 100 m. (3)

2.2.2 Calculate the distance run by the athlete in the 7,5 s. (2)

The athlete took 13,13 s to finish the 100 m.

2.2.3 Calculate his average velocity over the first 100 m distance. (3)

2.2.4 Determine his average velocity for the full 200 m. (2)

- 2.3 A cruise ship is being towed out of the harbour by two tugboats. One tugboat pulls with a force of 3 200 N on a bearing of 205° , while the other tugboat pulls with a force of 2 600 N directly south.
- 2.3.1 Draw a labelled free body diagram to represent only the forces applied by the tugboats to the cruise ship. (2)
- 2.3.2 Calculate the westerly component of the 3 200 N force. (3)
- 2.3.3 The cruise ship needs to go directly south to exit the harbour, but it is going off course. A third tugboat is requested to help. State the magnitude and direction of the minimum force which the third tugboat needs to apply to the cruise ship, to steer it safely out of the harbour. (2)
- [24]**

QUESTION 3 UPS AND DOWNS

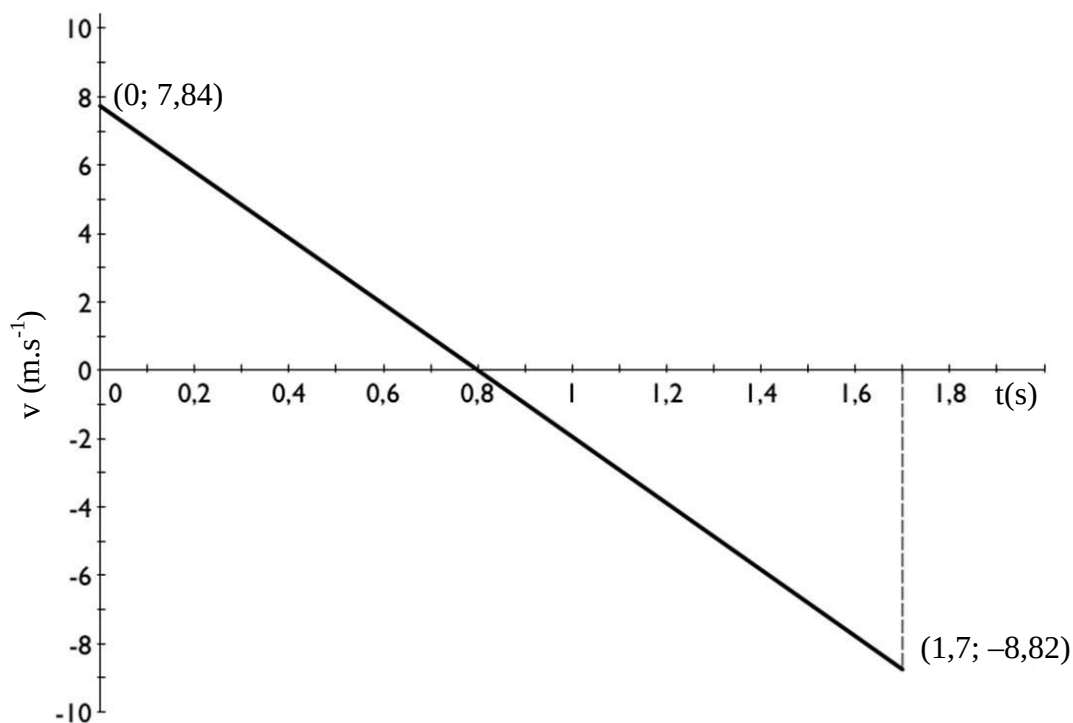
3.1 A gymnast is training by jumping on a trampoline.

3.1.1 Define *acceleration*. (2)

3.1.2 State the acceleration of the gymnast while she is in the air. (2)

3.1.3 While the gymnast is in contact with the trampoline mat, her acceleration is different to your answer in Question 3.1.2. Explain. (2)

Unfortunately the gymnast is still learning. She manages to bounce up, but she misses the trampoline on the way down. She leaves the trampoline mat with a velocity of $7,84 \text{ m.s}^{-1}$ up. The velocity-time graph for her **vertical motion** from the moment she leaves the mat to the moment she lands on the ground is given below. Up is the positive direction.

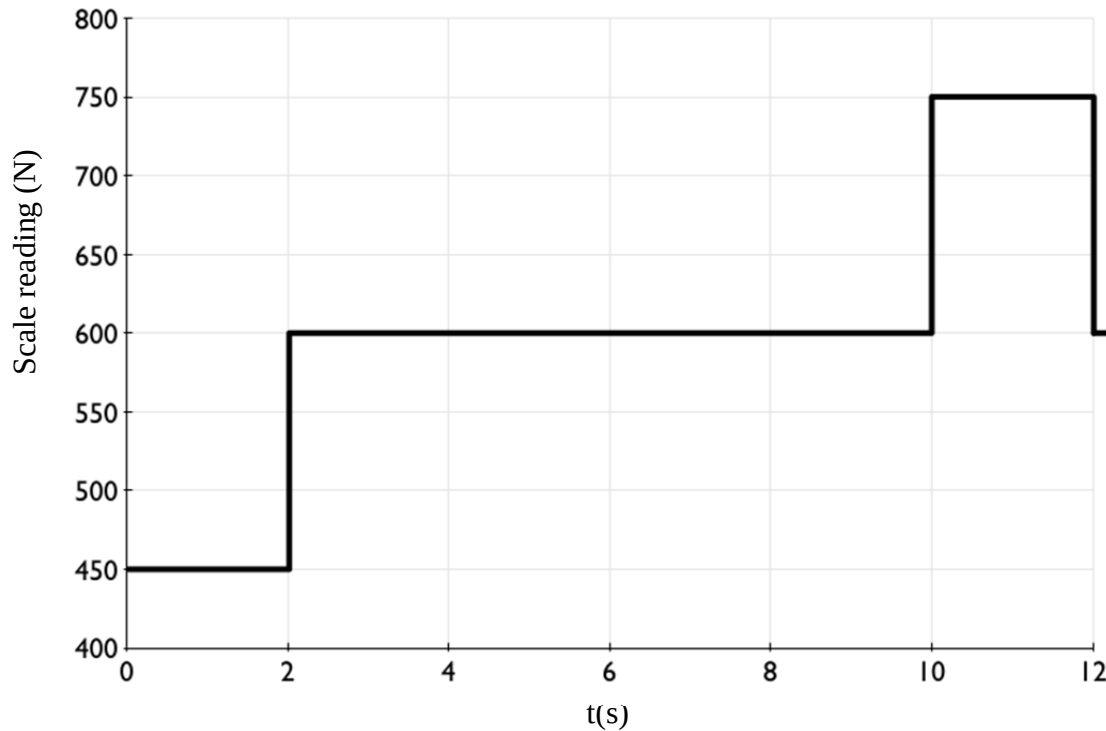


3.1.4 Use the graph to determine the height of the trampoline above the ground. (5)

3.1.5 Draw a sketch graph of the gymnast's displacement against time. Take displacement to be zero on the mat of the trampoline (frame of reference). Label A as the point she leaves the trampoline, B as the highest point and C as the point where she reaches the ground. No values are necessary on either of the axes. (3)

- 3.2 David is an enthusiastic physics student. He decides to take a bathroom scale to the Carlton Centre, the tallest building in South Africa, to conduct an experiment to check what he has learnt in class.

David gets into the lift halfway up the building and stands on the scale. The lift can accelerate uniformly up, accelerate uniformly down or have no acceleration. The lift starts moving at $t = 0$ s. The graph shows the scale reading over the next 12 s.



- 3.2.1 State in which direction (*up* or *down*) the lift is accelerating. Give a reason for your answer and draw a labeled free-body diagram of the forces acting on David.

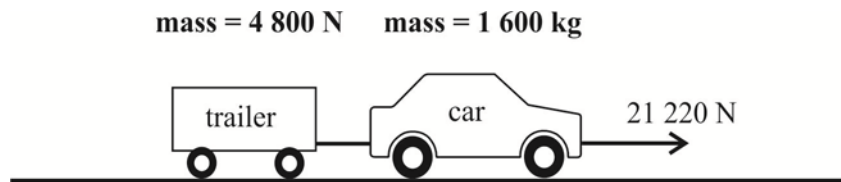
(3)

- 3.2.2 Determine David's mass.

(2)
[19]

QUESTION 4 MOVING DAY

- 4.1 Some boxes are loaded into a trailer to take to a new house. A car of mass 1 600 kg pulls the loaded trailer of mass 700 kg as shown in the diagram. There is a frictional force of 4 800 N acting on the trailer and a frictional force of 10 900 N acting on the car. The car's engine provides a driving force of 21 220 N.



- 4.1.1 State *Newton's second law of motion*. (4)
- 4.1.2 Draw a labelled force diagram to represent the horizontal forces acting on
- (a) the car.
- (b) the trailer. (5)
- 4.1.3 Calculate the magnitude of
- (a) the acceleration of the system, and
- (b) the tension in the tow bar. (5)
- 4.2 While moving house, a safe of mass 180 kg needs to be moved. It is too heavy to lift, so the movers tie a rope around the safe and pull it **horizontally** to the right. The coefficient of static friction between the safe and the ground is 0,5. The movers are not able to move the safe.
- 4.2.1 Draw a labelled free body diagram to represent all of the forces acting on the safe. (4)
- 4.2.2 Calculate the magnitude of the maximum frictional force. (4)
- The movers decide to pull on the rope so that the applied force makes an angle of 40° to the horizontal.
- 4.2.3 Why does pulling on the rope at an angle to the horizontal make it easier to move the safe? (2)
- 4.2.4 Calculate the magnitude of the force in the rope when it is at an angle of 40° to the horizontal, that will just cause the safe to start sliding. (4)

[28]

QUESTION 5 MOMENTUM, WORK, ENERGY & POWER

5.1 Two ice skaters, Chris and Robert are standing at rest near the middle of the ice rink. Chris and Robert push off against each other. Robert has a greater mass than Chris.

5.1.1 Immediately after push off, which skater, if either, has

(a) the greater momentum?

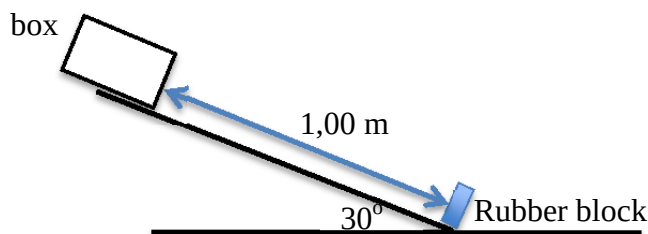
(b) the greater speed?

(2)

5.1.2 Explain your answers to Question 5.1.1.

(3)

5.2 A 0,5 kg box is released from rest 1,00 m from the bottom of a frictionless 30° ramp, as shown in the diagram below.



The box slides down the slope and bounces off a rubber block at the bottom of the slope.

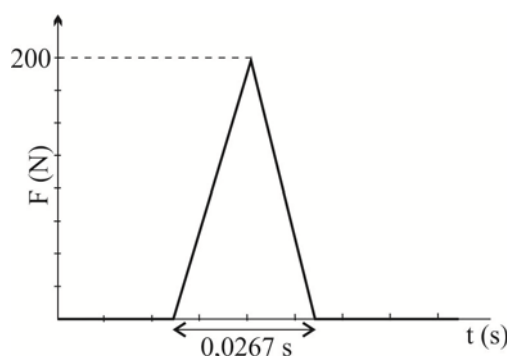
5.2.1 Calculate the gravitational potential energy of the box as it is released.

(4)

5.2.2 Calculate the speed of the box just before it runs into the rubber block.

(3)

The following graph represents the force acting on the box during the collision.



5.2.3 Use the graph to determine the magnitude of the impulse experienced by the box during the collision.

(3)

5.2.4 Calculate the speed of the box immediately after it bounces off the rubber block. (4)

5.2.5 State **two** ways in which **the graph would change** if the rubber block was replaced with a granite block and the box has the same change in momentum. Give a reason for your answer.

(2)

[23]

QUESTION 6 FIELDS

- 6.1 Apollo 11 was the first manned spaceship to travel to and land on the moon. The Earth has a mass of $6,0 \times 10^{24}$ kg while the Moon has a mass of $7,3 \times 10^{22}$ kg. The distance from the Earth to the Moon is $3,8 \times 10^8$ m.

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

- 6.1.2 At some position between the Earth and the Moon, Apollo 11 would have experienced a resultant force of zero.

(a) Explain how this is possible. (2)

(b) Calculate the distance from the Earth when the resultant force on the spacecraft is zero. (4)

- 6.2 A small plastic bead has been charged to $-2,0 \times 10^{-8}$ C.

6.2.1 Draw a diagram to represent the electric field around this bead. (2)

6.2.2 Calculate the magnitude of the electric field a distance of 0,03 m from the centre of the bead. (3)

6.2.3 Calculate the force experienced by an electron that is 0,03 m from the centre of the bead. (4)

- 6.3 Gravitational fields and electric fields are similar to each other yet different.

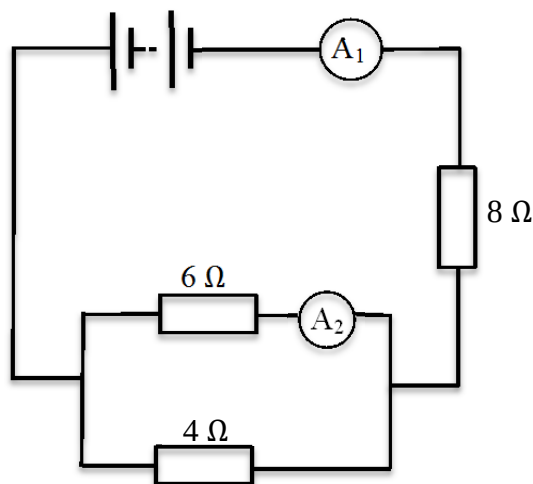
6.3.1 State one similarity between gravitational and electric fields. (1)

6.3.2 State one difference between gravitational and electric fields. (1)

[20]

QUESTION 7 ELECTRIC CIRCUITS

- 7.1 In the following circuit the resistances of the ammeters, cells and connecting wires are negligible.



The reading on the ammeter A_1 is 2 A.

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

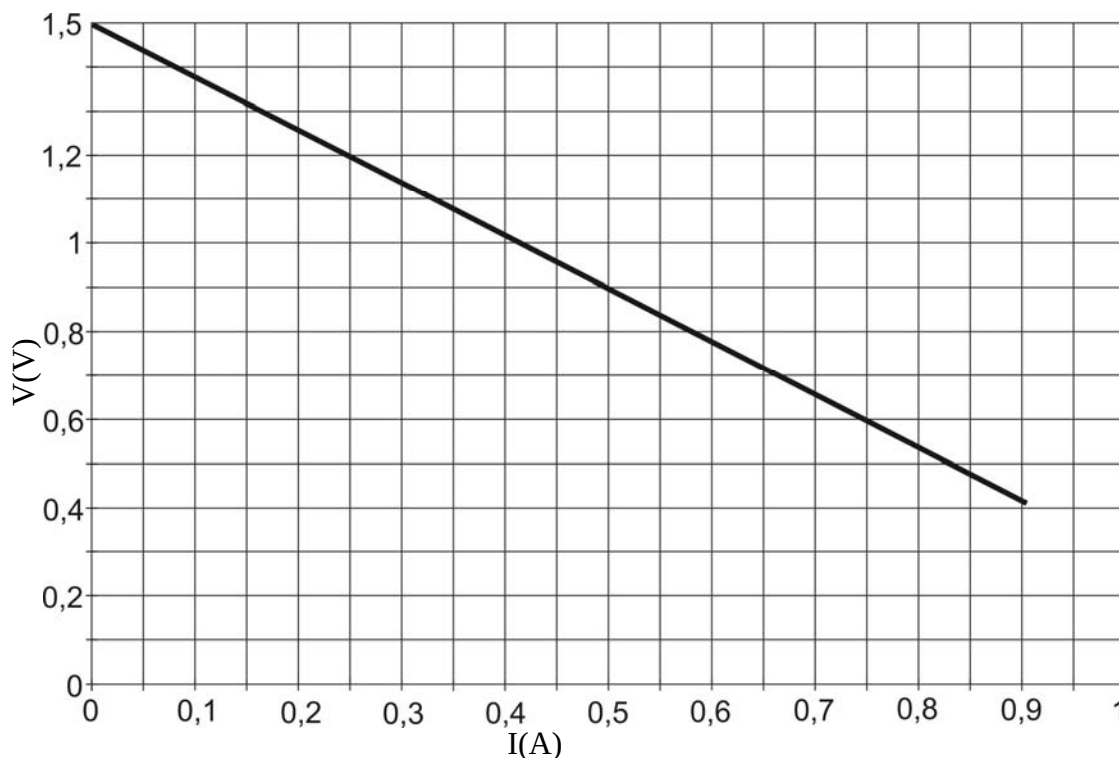
7.1.2 Determine the potential difference across the 8Ω resistor. (3)

7.1.3 Calculate the current measured by the ammeter A_2 . (3)

- 7.2 A cell has an emf E and internal resistance r and is connected to an external circuit. There is a current I in the circuit when the potential difference across the terminals of the cell is V .

7.2.1 Define *emf*. (2)

The graph below shows the variation of V with I for the cell.



7.2.2 Sketch a diagram of the circuit that could have been used to obtain the data used to plot the above graph. (3)

7.2.3 Use the graph to determine the emf of the cell. Explain how you obtained your answer. (2)

7.2.4 (a) Use the equation $V = \text{emf} - Ir$, together with the graph, to determine the physical quantity represented by the gradient of the graph. Clearly indicate your reasoning. (2)

(b) Calculate the magnitude of the physical quantity represented by the gradient of the graph. (3)

- 7.3 A motor is used to raise a concrete statue of mass 350 kg through a height of 2,5 m onto the top of a building. It takes 5 minutes to lift the statue into position.

7.3.1 Calculate the power required to lift the statue. (4)

The motor is connected to a 24 V supply and has a resistance of $15\ \Omega$.

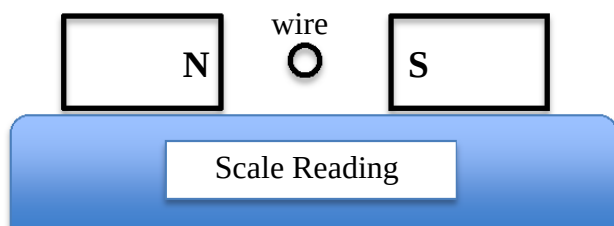
7.3.2 Calculate the percentage efficiency of the motor. (5)

[29]

QUESTION 8 MAY THE FORCE BE MEASURED

Lauren and Tayla read in their textbook, "a force acts on a current carrying conductor placed in a magnetic field". They decide to carry out an investigation to determine the relationship between the current in the wire and the magnitude of the force experienced.

They set up the following apparatus. Two magnets with their opposite poles facing each other were placed on a scale. A stiff piece of copper wire was **fixed in position** between the poles of the magnets (as shown in the diagram below).



The girls altered the current in the wire and noticed that the scale reading changed. They recorded their results in a table.

Current (A)	Scale reading (N)	Change in scale reading (mN)
0,0	2,080	0
0,5	2,163	83
1,0	2,338	175
1,5	2,606	268
2,0	2,947	341
2,5	3,382	435
3,0	3,908	526

- 8.1 Draw a sketch showing the magnetic field around a straight, current carrying conductor. Represent the current as flowing into the page. (2)
- 8.2 State the independent variable. (1)
- 8.3 The reading on the scale increases as the current increases. Explain the **origin** of the force being measured. (2)
- 8.4 Does the current flow 'into the page' or 'out of the page' in the diagram above? Explain your answer. (3)
- 8.5 Plot a graph of **change in scale reading** in mN against **current** in A. (7)
- 8.6 Describe the relationship between the force on the wire and the current in the wire. Which features of the graph lead you to your conclusion? (3)
- 8.7 Why was it more appropriate to plot the change in the scale reading rather than the scale reading itself? (2)

[20]

QUESTION 9 PHOTONS AND ELECTRONS

9.1 Aluminium has a work function of $W_0 = 4,08 \text{ eV}$.

9.1.1 Define the term '*work function*'. (2)

9.1.2 Calculate the threshold frequency of light that is required to release an electron from an aluminium plate. (4)

There are two sources of light in the laboratory that you can use to shine onto the aluminium surface.

Light Source	Wavelength (nm)
A	400
B	250

9.1.3 Use a calculation to help you decide which light source will be able to release electrons from the aluminium plate. (4)

9.1.4 If you used the light source that ejects electrons, what would you do to ensure more electrons are emitted per second from the metal plate? Explain your answer. (2)

9.2 The Bunsen burner was invented by Robert Bunsen, as he needed a very hot, clean flame to investigate the coloured lights emitted by different elements when they are heated. Bunsen was the first person to study the 'emission spectra' of elements.

9.2.1 Use an energy level diagram to help explain the source of atomic emission spectra. (3)

9.2.2 Emission spectra can be used to identify elements. Why does each element have a unique emission spectrum? (2)

[17]

Total: 200 marks