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Preliminary Exam

+ 10 min reading time

- This paper consists of 26 pages (including the front page). Ensure that your paper is complete.
- Take note of the mark allocation and read each question thoroughly.
- Answer all questions on the question paper in the space provided.
- Spare folio paper is available with your invigilator. If you run out of space for a question, please use this folio paper. Clearly indicate this at the question to ensure that your answer is marked in full.
- All final numerical answers should be given to a maximum of **2 decimal places**, showing all working where necessary.
- A non-programmable calculator may be used.
- Use a pencil when drawing diagrams and graphs.
- Useful formulae and constants are provided separately.

Choice:

[illegible][illegible]

Acknowledgements: Siyavula, ieb, CIE, Kevin Smith (2020) Berlut books (2020)

Question 1: Multiple Choice Questions

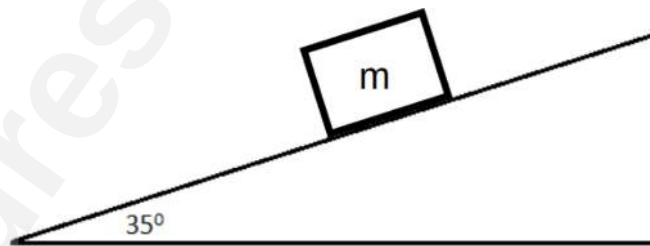
[20]

1. On the grid below, make a cross (X) in the box corresponding to the letter that you consider to be correct.

Only one option is correct.

1.1	A	B	C	D	(2)
1.2	A	B	C	D	(2)
1.3	A	B	C	D	(2)
1.4	A	B	C	D	(2)
1.5	A	B	C	D	(2)
1.6	A	B	C	D	(2)
1.7	A	B	C	D	(2)
1.8	A	B	C	D	(2)
1.9	A	B	C	D	(2)
1.10	A	B	C	D	(2)

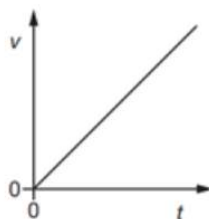
- 1.1. Consider mass **m** resting on a rough slope. The mass, **m**, just starts to slide when the slope makes an angle of 35° with the horizontal.



Which formula best describes the coefficient of static friction μ_s ?

- A. $\mu = \frac{mg \sin 35}{mg} = \sin 35$
 B. $\mu = \frac{\cos 35}{\sin 35}$
 C. $\mu = \frac{\sin 35}{\cos 35}$
 D. $\mu = \frac{mg \cos 35}{mg} = \cos 35$

- 1.2. The graph below shows the velocity of an object falling from rest in a vacuum with time.



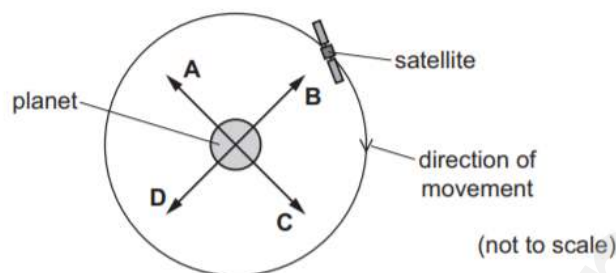
Which graph correctly shows the velocity with time of the same object moving from rest in **air**. It does not reach terminal velocity. Note the graphs are drawn to the same scale as the graph above.

A.		B.	
C.		D.	

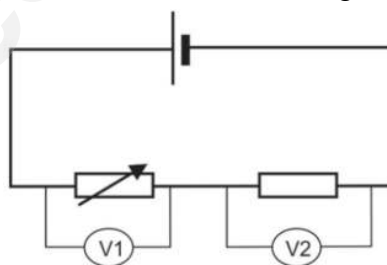
- 1.3. A stone is thrown up into the air. Which correctly describes the velocity and the direction of the acceleration of the stone as it moves up and as it falls back down to the ground?

	As the stone moves up		As the stone falls down	
	$v \text{ (m.s}^{-1}\text{)}$	$a \text{ (m.s}^{-2}\text{)}$	$v \text{ (m.s}^{-1}\text{)}$	$a \text{ (m.s}^{-2}\text{)}$
A.	increasing	up	decreasing	up
B.	increasing	down	decreasing	down
C.	decreasing	up	increasing	up
D.	decreasing	down	increasing	down

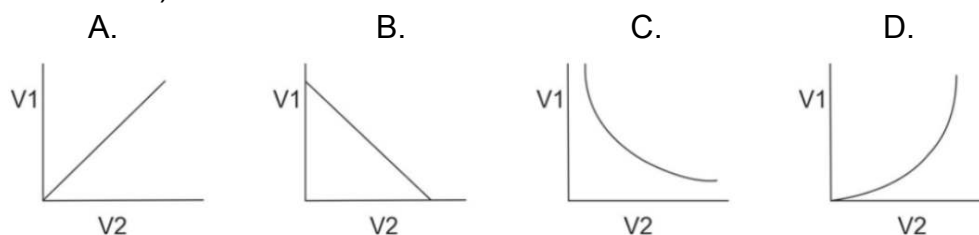
- 1.4. A satellite is orbiting a planet in a circular path as shown in the diagram below. The satellite exerts a force on the planet. Which letter below shows the direction of this force?



- 1.5. A rocket of mass m (when empty), carries fuel with the same mass of m . The rocket and the fuel travel at a speed of v . The engine of the rocket is ignited and all of the fuel is burnt increasing the speed of the rocket to $2v$. What happens to the kinetic energy of the rocket?
- It doubles.
 - It halves.
 - It increases by a factor of four.
 - It remains the same.
- 1.6. An electrically charged aluminium ball is at rest on a wooden table. Which fields will exist due to the ball?
- Electrostatic, gravitational and magnetic
 - Electrostatic and gravitational only
 - Electrostatic and magnetic only
 - Gravitational and magnetic only
- 1.7. The circuit below is set up so that the rheostat has a resistance that can be increased or decreased as desired. When the rheostat is adjusted, the readings on the voltmeters V_1 and V_2 change.



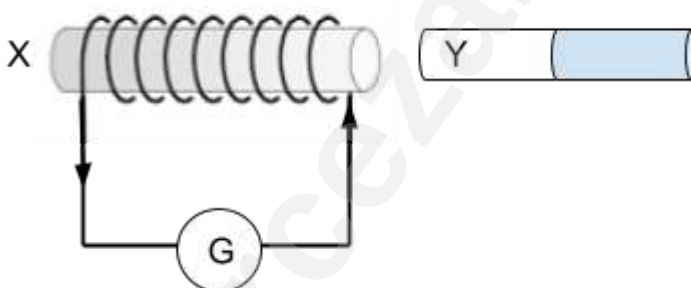
Which one of the following graphs best represents the relationship between the readings on V_1 and V_2 ? (Assume that the cell has negligible internal resistance.)



- 1.8. A battery consists of three identical cells in parallel. Which row below correctly shows a possible unit as well as the magnitude of the electromotive force of the battery?

	unit	magnitude
A.	N.V^{-1}	the sum of the electromotive forces of all three cells
B.	J.C^{-1}	the sum of the electromotive forces of all three cells
C.	N.V^{-1}	the electromotive force of one of the cells
D.	J.C^{-1}	the electromotive force of one of the cells

- 1.9. A magnet is moved so that it creates a current in the direction shown in the solenoid below:



Which option below would produce this current?

	Polarity at X	Polarity of Y	Direction of magnet movement
A.	North	South	Away from the solenoid
B.	North	North	Away from the solenoid
C.	South	North	Towards the solenoid
D.	South	South	Towards the solenoid

- 1.10. A metal is placed on the plate of a negatively charged electroscope. The plate is radiated using yellow light. Which of the following would cause electrons to leave at a faster speed?

- A. Using blue light
- B. Increasing the intensity of the light
- C. Increasing the wavelength of the yellow light
- D. Increasing the work function by using another metal

Question 2: Kinematics

[21]

2. Cameron and Luke are playing with a slingshot. Luke throws a ball vertically up in the air with a velocity of $24,5 \text{ m.s}^{-1}$. Ignore air resistance.

- 2.1. Define *velocity*. (2)

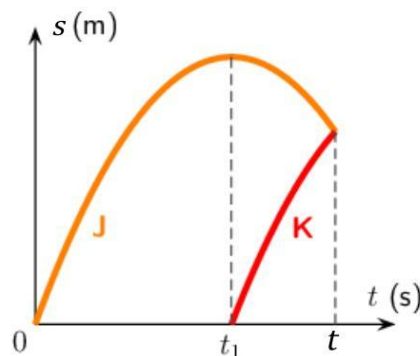
- 2.2. Convert $24,5 \text{ m.s}^{-1}$ to km.h^{-1} _____ (1)

- 2.3. Calculate the time taken for the ball to reach the maximum height. (3)

At the exact moment that the ball reaches its maximum height (t_1), Cameron shoots a small stone directly upwards from the ground at the ball at a velocity of $u \text{ m.s}^{-1}$.

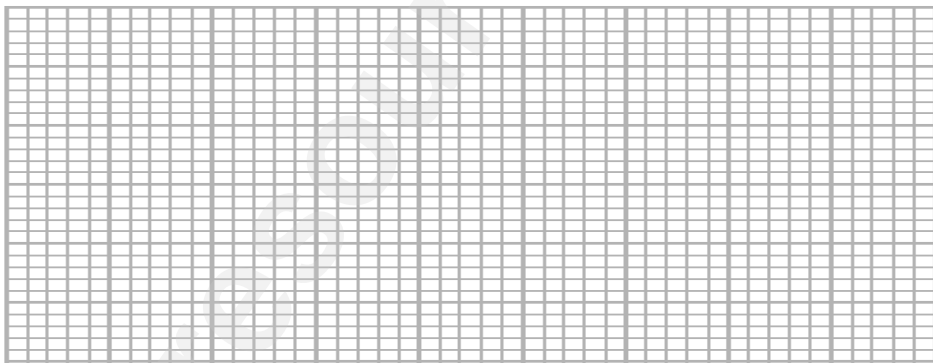
- 2.4. The stone hits the ball at a height of $29,4 \text{ m}$ above the ground. Calculate the speed of the ball as the collision takes place. (3)

The stone and the ball collide at time t after the ball was thrown in the air. The position time graph below shows the motion of the ball (J) and stone (K).

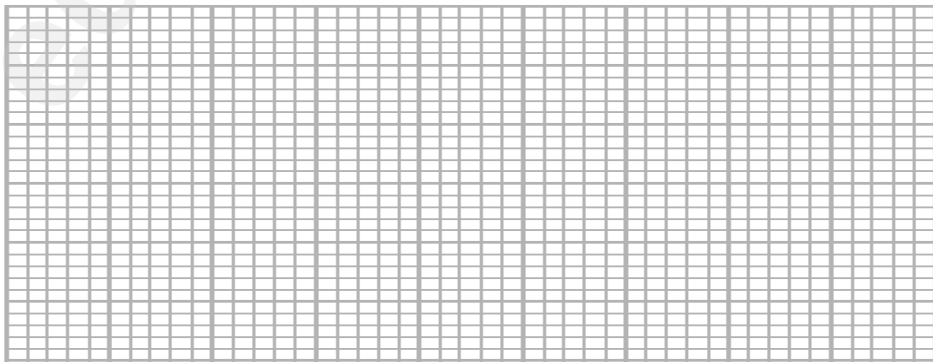


- 2.5. Show by calculation that the stone was shot with an initial velocity of $61,25 \text{ m.s}^{-1}$. (6)

- 2.6. Sketch a velocity-time graph for the entire motion of the **ball** up until the collision. Include any known values. (3)



- 2.7. Sketch an acceleration time graph for the entire motion of the **ball** up until the collision. Include any known values. (3)



Question 3:

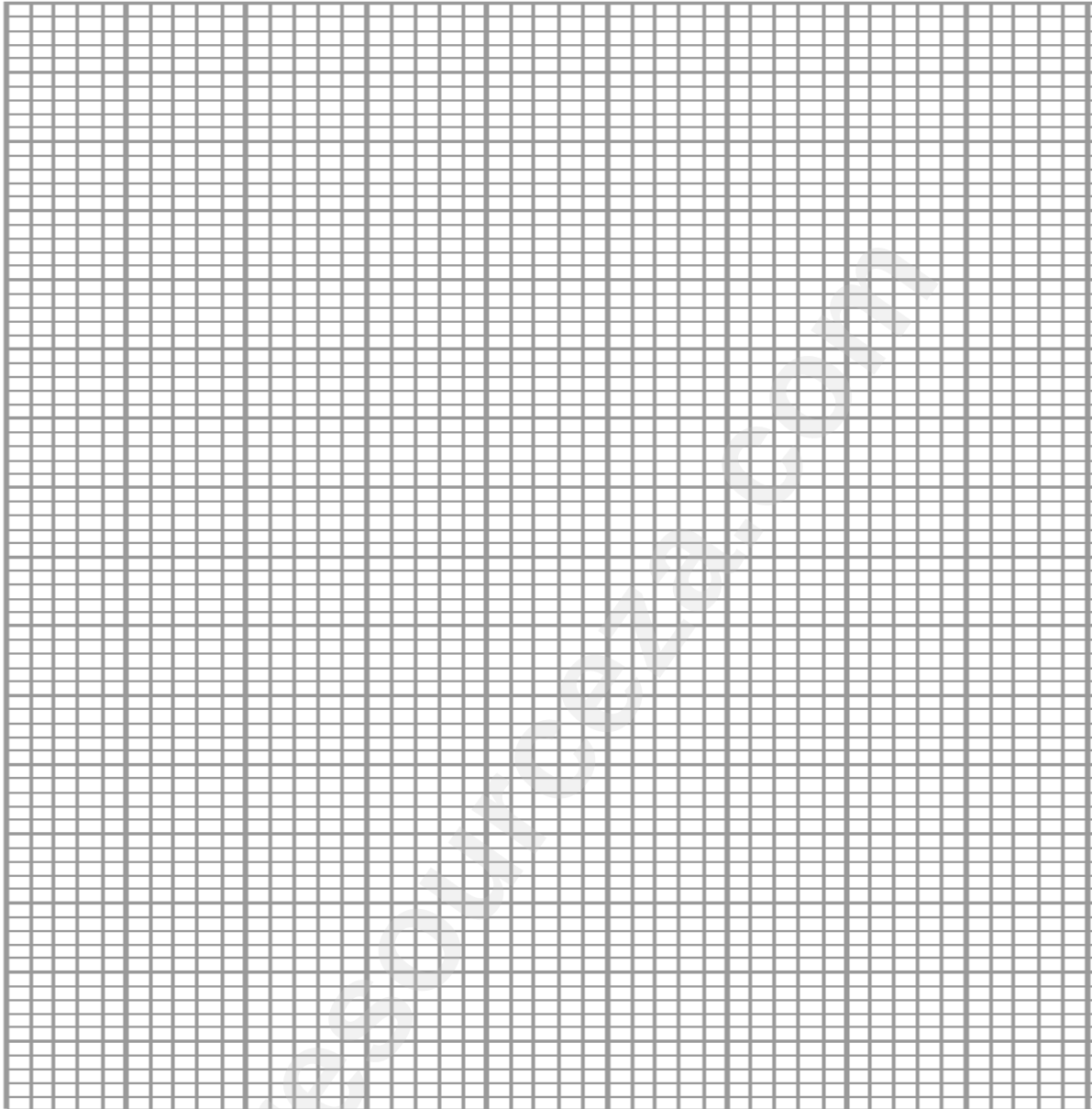
[21]

3. Matovya set out to determine the time taken for a tennis ball to hit the ground when dropped from windows of different heights at school. Assume constant acceleration.

Her results are as follows:

Height when dropped (m)	Time taken to hit the ground ² (s ²)
1,2	0,25
2,0	0,45
5,2	1,35
10,0	2,27
13,2	2,85
17,0	3,85

- 3.1. State a controlled variable, not already mentioned in this investigation. (2)
-
- 3.2. Using the graph grid on the next page, plot a graph of time² on the y-axis vs height on the x-axis. Include a line of best fit. (6)
- 3.3. Calculate the gradient of the line of best fit. Show clearly the points used in your calculation on your graph. (4)
- 3.4. State the unit that would be applicable to the gradient value. (2)
-



- 3.5. Using a suitable equation of motion and the equation for a straight line ($y = mx + c$). Provide an expression for the gradient in terms of the acceleration, a . Note: No numerical values from your graph need to be used. (3)

3.6. Hence, calculate the acceleration of the tennis ball. (2)

3.7. Explain why the acceleration calculated in question 3.6 may differ from the known value of acceleration due to gravity of $9,8 \text{ m.s}^{-2}$. (2)

Question 4: Newton

[27]

4. Madison is going on holiday with friends. She pulls her bag across the floor at an angle of 35° from the vertical with a constant velocity.

The coefficient of friction between the floor and the wheels is 0,6. The floor exerts a frictional force of 27 N on the wheels of the bag.



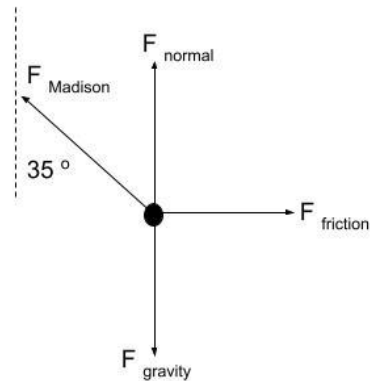
- 4.1. Define *frictional force*.

(2)

- 4.2. Calculate the normal force acting on the bag while being pulled.

(3)

A free body diagram for the bag is provided alongside.



- 4.3. Calculate the magnitude of the weight of the bag.

(6)

- 4.4. State a Newton 3 action reaction pair for one of the forces acting on the bag. State the name and direction of each force. (3)

Action Force: _____

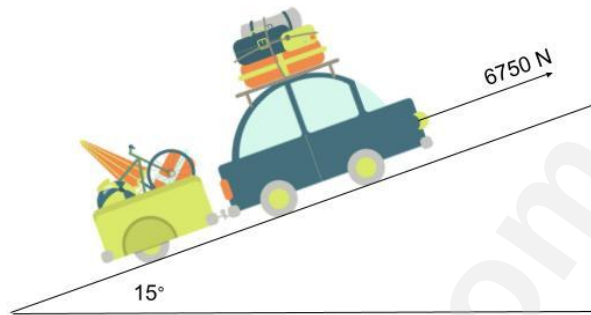
Reaction Force: _____

- 4.5. On their way, Madison is driving at a constant velocity. She lifts her foot off the accelerator causing the engine to no longer apply a force.

- 4.5.1. State *Newton's second law*. (2)

- 4.5.2. Use the law mentioned in question 4.5.1. to describe the motion of the car after Madison lifts her foot off the accelerator. (2)

- 4.6. Madison drives the 1200 kg car which tows a 400 kg trailer up a 15° hill. The engine applies a constant 6750 N of force as shown below. The towbar connecting the trailer and car is of negligible mass and is considered part of the car.



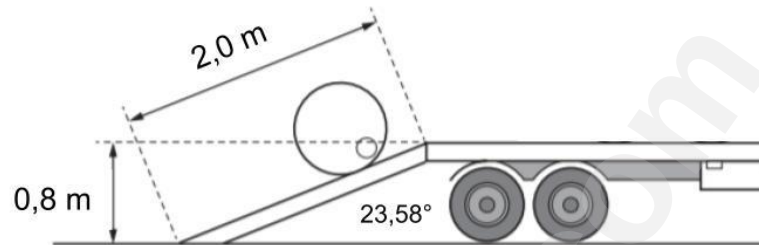
Ignore the effects of friction

- 4.6.1. Draw a free body diagram showing all the forces acting on the car while driving up the hill. (4)
- 4.6.2. Apply Newton's second law individually to the trailer and the car to calculate the magnitude of the force of the car on the trailer. (5)

Question 5: WEP Jp

[30]

5. A worker loads barrels with a weight of 180 kg onto a truck. The back of the truck is 0,8 m above the horizontal surface of the road. The barrels are pushed up a plank of length 2,0 m which rests at an angle of $23,58^\circ$ to the surface of the road.



- 5.1.1. Define *work done*. (2)

- 5.1.2. Calculate the work done against gravity on the barrel as it is pushed up the slope. (3)

The barrel is pushed from rest and accelerates constantly to reach a velocity of $0,5 \text{ m}\cdot\text{s}^{-1}$ at the top of the slope.

- 5.1.3. Calculate the change in kinetic energy of the barrel. (3)

- 5.1.4. The slope provides a force of friction of 900 N. Using energy principles, calculate the magnitude of the force applied by the man to move the barrel up the ramp. (5)

Once the barrel is at the top of the slope, the worker allows it to roll to a stop on the horizontal surface. The same frictional force is present.

- 5.1.5. State the work-energy theorem. (2)

- 5.1.6. Calculate the distance it would take for the barrel to come to a stop. Assume it does not collide with anything else. (4)

- 5.2. Another barrel of mass 180 kg is at rest on the frictionless workshop floor. It is knocked by a forklift of mass 4 000 kg moving at a velocity of $1,5 \text{ m}\cdot\text{s}^{-1}$. After the collision the forklift recoils at $0,1 \text{ m}\cdot\text{s}^{-1}$.

- 5.2.1. Calculate the momentum of the forklift before the collision. (3)

5.2.2. Calculate the velocity of the barrel after the collision. (4)

5.2.3. If one were to change the impulse of the barrel in this collision, what quantity would you need to alter? Note the masses and velocities of the objects cannot be changed. (1)

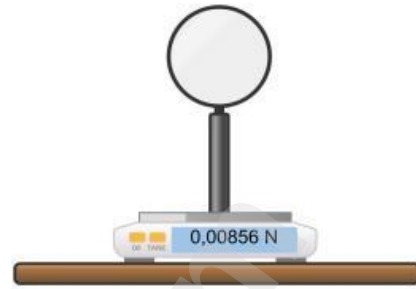
5.2.4. How would your alteration suggested in question 5.2.3 change the impulse? Use an equation to support your answer. (3)

Question 6: Fields

[15]

6. Darshana and Kimaya are playing with the electrostatic apparatus left out in the science labs.

Kimaya charges a metal sphere to a charge of $+ 3,5 \text{ nC}$. The sphere and its stand is placed on top of a scale that records a weight of $8,56 \times 10^{-3} \text{ N}$.



Darshana brings another charged sphere vertically above Kimaya's sphere so that the centres of the spheres are held $5,5 \times 10^{-3} \text{ m}$ apart. The reading on the scale decreases.

- 6.1.1. Is Darshana's sphere charged negatively or positively? (1)

- 6.1.2. Explain your answer in question 6.1.1. (2)

- 6.1.3. State *Coulomb's Law*. (2)

- 6.1.4. Darshana's sphere has a charge of magnitude 5,84 nC. Calculate the new reading on the scale. (5)

Darshana's sphere is removed.

- 6.2. The girls wonder how much further from the center of the Earth the stand and sphere would need to be in order to quarter the reading on the scale without the use of electrostatic forces.
Show how many times further it would need to be. (2)

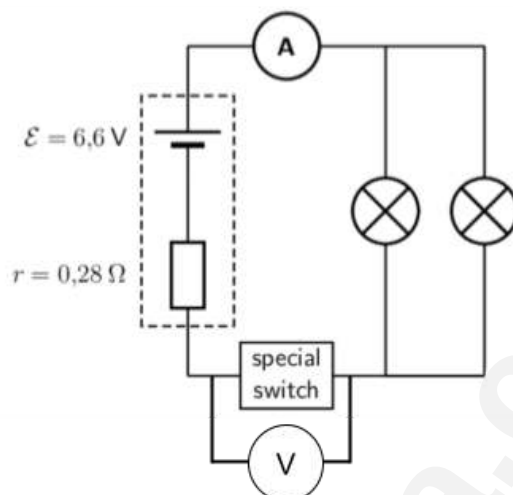
- 6.3. Calculate the strength of the gravitational field of Earth at the point calculated in question 6.2.

Note: The Earth has a mass of 6×10^{24} kg and a radius of $6,4 \times 10^6$ m (3)

Question 7: Circuits

[26]

7. Thaeglan has a headlamp that has two light bulbs connected in parallel.



The headlamp has a special switch which acts like a rheostat and that has three functions:

- When it is in the **off** position the switch acts as an open switch.
- When it is in the **dim** position, the switch acts as resistor with a resistance of $0,9\ \Omega$.
- When it is in the **bright** position, the switch has no resistance.

- 7.1. Define *resistance*. (2)

- 7.2. Calculate the individual resistance of the **identical** light bulbs if their effective resistance is $0,6\ \Omega$. (3)

7.3. 15 C passes through the ammeter in 2 seconds when the headlamp is in the **bright** position.

7.3.1. Calculate the reading on the ammeter. (3)

7.3.2. State the current through one of the light bulbs. (1)

7.3.3. Calculate the rate of energy transferred by one light bulb. (3)

7.4. Calculate the ammeter reading when the switch is in the **dim** position. (4)

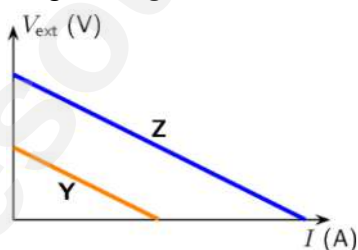
7.5. Calculate the voltage across the switch when it is in the **dim** position. (3)

7.6. State the reading on the voltmeter across the special switch when in the following positions.

7.6.1. The “off” position. Value: _____ (2)
Explanation:

7.6.2. The “bright” position. Value: _____ (2)
Explanation:

7.7. Theaglan swaps out the cell for a new cell which has half the emf and the same internal resistance compared to the old cell.
The graphs below show how the potential difference across the cell changes with the current passing through the two different cells that Theaglan used.



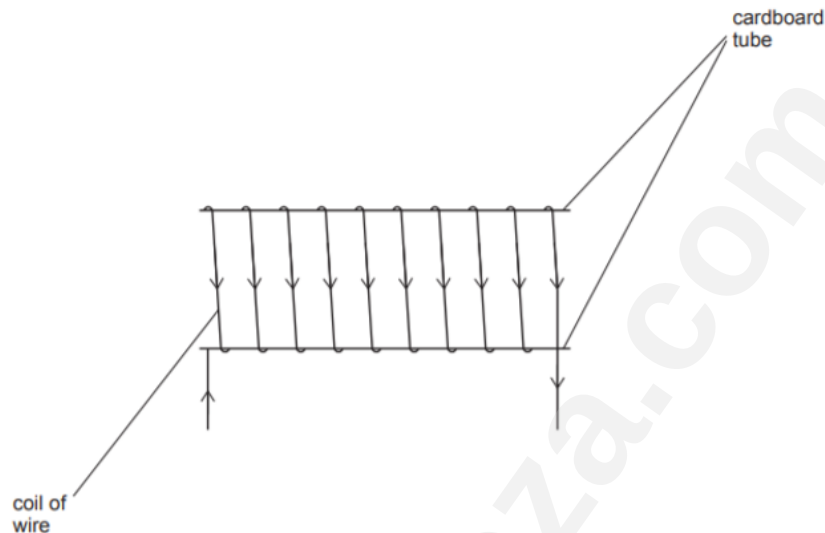
7.7.1. Which graph (Y or Z) is for the new cell that Thaeglan used? (1)

7.7.2. Referring to features of the graph above, give a reason for your answer to question 7.7.1. (2)

Question 8: Electrodynamics

[25]

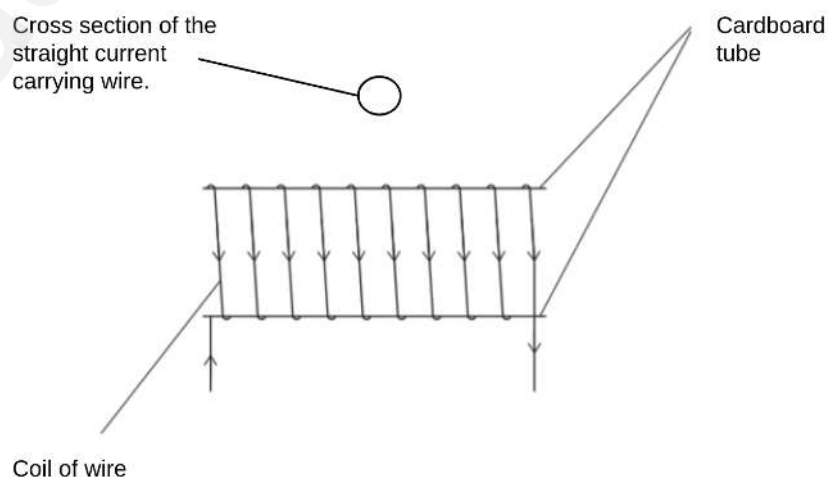
8. The diagram below shows a coil of wire wrapped around a cardboard tube. The direction of the electric current in the wire is shown by the arrows.



When the current is switched on, a magnetic field is created.

- 8.1. On the diagram above, draw in the magnetic field lines inside and around the coil. (3)
- 8.2. Clearly indicate the direction of the South pole on the diagram. (1)
- 8.3. Name one way in which the strength of the magnetic field can be increased. (1)

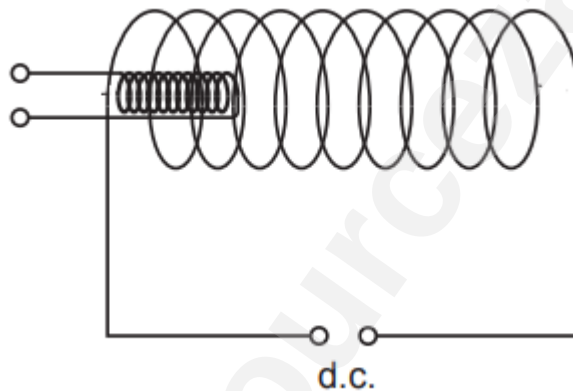
- 8.4. A straight, current-carrying conductor is placed above the coil of wire as shown in the diagram below. The wire experiences a force towards the coil.



- 8.4.1. Explain in detail why the wire experiences a force. (2)

- 8.4.2. Show the direction of the current in the wire by drawing a cross or dot in the circle provided on page 22. (2)

- 8.5. A small solenoid with 350 turns is stationary inside the coil as shown below. The small solenoid is connected to a sensitive ammeter.



- 8.5.1. State *Faraday's Law of electromagnetic induction*. (2)

The ammeter connected to the small solenoid shows a reading of zero.

- 8.5.2. Explain why the reading on the ammeter is zero. (2)

- 8.5.3. State 2 different methods in which you can use the shown apparatus to produce a current in the small solenoid. (2)

Okuhle suggests that this apparatus can be used to make a transformer. Ms Morrow confirms that this is true if the supply current is changed to an alternating current.

- 8.5.4. Why must the supply current in a transformer be an alternating current? (3)

The coil has 100 turns and their transformer is 90% efficient.

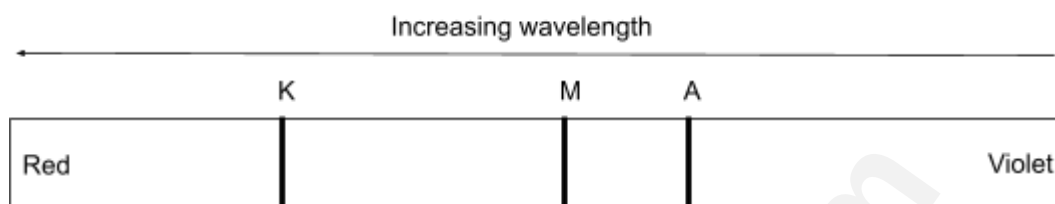
- 8.5.5. Define *efficiency*. (2)

- 8.5.6. Calculate the current in the small solenoid when Okuhle connects the coil to a 2,5 A, 240 V supply. (5)

Question 9: Photons and Electrons

[15]

9. The emission lines, K, M and A for an atom are shown in the diagram below:



- 9.1. Place the letters of the emission lines alongside their most likely frequency in the table below. (2)

Emission Line	Frequency (Hz)
	$6,56 \times 10^{14}$
	$5,17 \times 10^{14}$
	$4,19 \times 10^{14}$

- 9.2. Calculate the wavelength of the light associated with the emission of line K. (3)

- 9.3. Define *work function*. (2)

- 9.4. The work function of mercury is 4,5 eV. Which of the emissions would cause photoelectrons to be emitted from the surface of mercury? (5)

9.5. Explain your answer to question 9.4. (3)

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