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TOTAL MARKS

INTERNATIONAL SECONDARY CERTIFICATE EXAMINATION
NOVEMBER 2023

PHYSICAL SCIENCES: PAPER I

EXAMINATION NUMBER

Time: 3 hours 200 marks

PLEASE READ THE FOLLOWING INSTRUCTIONS CAREFULLY

1. This question paper consists of 31 pages and a Data Sheet of 2 pages (i–ii). Please check that your question paper is complete.
2. **Answer ALL the questions on the question paper and hand it in at the end of the examination. Remember to write your examination number in the space provided above.**
3. Read the questions carefully.
4. Use the data and formulae whenever necessary.
5. Show your working in all calculations.
6. Units need not be included in the working of calculations, but appropriate units should be shown in the answer.
7. Answers must be expressed in decimal format, not left as proper fractions.
8. Where appropriate, express answers to TWO decimal places.
9. It is in your own interest to write legibly and to present your work neatly.
10. THREE blank pages (pages 29–31) are included at the end of the paper. If you run out of space for a question, use these pages. Clearly indicate the question number of your answer should you use this extra space.

FOR MARKER'S USE ONLY

Question	1	2	3	4	5	6	7	8	9	Total
Marks	20	33	20	13	29	13	29	24	19	**200**
Marked										
Moderated										

QUESTION 1

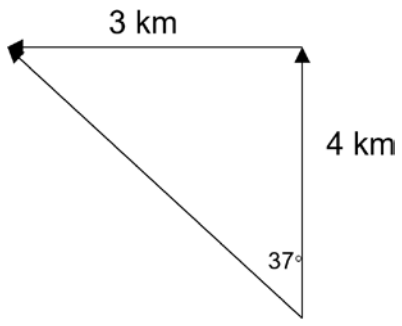
Answer these questions on the multiple-choice answer grid below. Make a clear cross (X) in the box corresponding to the letter that you consider to be correct. Every question has only one correct answer.

A	B	C	D

Here the option C has been marked as an example.

1.1	**A**	**B**	**C**	**D**
1.2	**A**	**B**	**C**	**D**
1.3	**A**	**B**	**C**	**D**
1.4	**A**	**B**	**C**	**D**
1.5	**A**	**B**	**C**	**D**
1.6	**A**	**B**	**C**	**D**
1.7	**A**	**B**	**C**	**D**
1.8	**A**	**B**	**C**	**D**
1.9	**A**	**B**	**C**	**D**
1.10	**A**	**B**	**C**	**D**

1.1 A student walks 4 km due north in one hour and 3 km due west in the next hour. What is his resultant displacement after two hours?

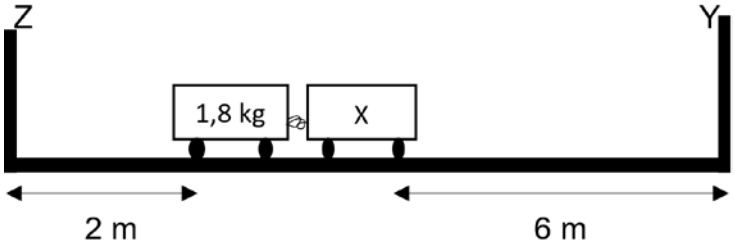


A 7,0 km
B 2,5 km, 37° N of W
C 5 km, 323°
D 5 km, 37° N of W (2)

1.2 An object is suspended from a spring balance reading 80 N when the lift is at rest. If the balance reading is 100 N, the lift is moving …

A downwards and increasing in speed.
B upwards and increasing in speed.
C downwards at constant speed.
D upwards at constant speed. (2)

1.3 Two trolleys are placed on a horizontal surface. The trolleys separate when a compressed spring between them is released. They hit the buffers Y and Z simultaneously. What is the mass of X in kg?



A 0,2
B 0,3
C 0,6
D 0,9 (2)

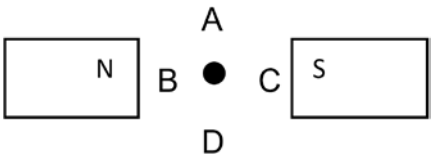
1.4 The diameter of the planet Jupiter is 11 times that of the earth, while its mass is 420 times that of the earth. If the gravitational acceleration near the surface of the earth is 9,8 $m.s^{-2}$, which one of the following will be the acceleration near the surface of Jupiter?

A $\frac{420 \times 9,8}{11^2}$
B $\frac{11^2 \times 9,8}{420}$
C $\frac{420 \times 9,8}{11}$
D $\frac{11 \times 9,8}{420}$ (2)

1.5 Two identical small metal balls, P and Q, are standing on isolated stands. Ball P has a charge of 4 nC and ball Q a charge of -4 nC. The two balls exert a force **F** on each other when they are a distance **d** apart. They are brought into contact with each other and then placed back **½ d** from each other. What is the electrostatic force they now exert on each other?

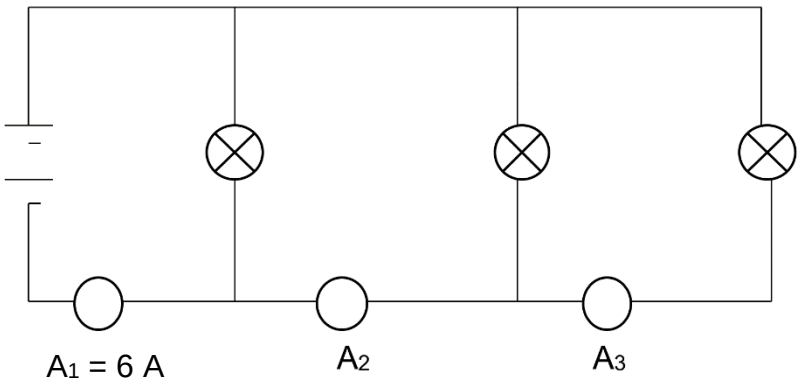
A 4F
B 2F
C F
D 0 (2)

1.6 A current carrying conductor is placed between two magnets as shown in the sketch. In which direction will the conductor experience a force?



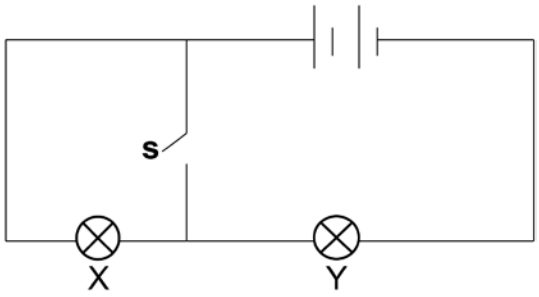
(2)

1.7 In the circuit shown below, all the bulbs are identical. If A_1 has a reading of 6 A, what will the reading be on A_2?



A 2 A
B 3 A
C 4 A
D 6 A (2)

1.8 Two identical lamps, X and Y, are connected in series as shown in the sketch. How will the brightness of the lamps change when the switch **s** is closed?



	X	Y
A	Brighter	Brighter
B	Weaker	Weaker
C	Brighter	Will not burn
D	Will not burn	Brighter

(2)

1.9 A boy with a mass of 60 kg climbs up 50 steps. Each step is 200 mm high, 250 mm wide and has a breadth of 1,5 m. The work done against the gravitational force is

A 600 J
B 117,6 J
C 588 J
D 5 880 J (2)

1.10 The SI unit for magnetic flux is

A newton per ampere-meter
B weber
C weber per square meter
D tesla (2)

[20]

QUESTION 2

2.1 Athlete A, competing in a 100 m race, crosses the finish line in 10,5 s. At the start athlete A accelerates uniformly to a top speed in 2,3 s and then remains at a constant speed for the remainder of the race.

Calculate:

2.1.1 the average speed of athlete A over the total distance.

(3)

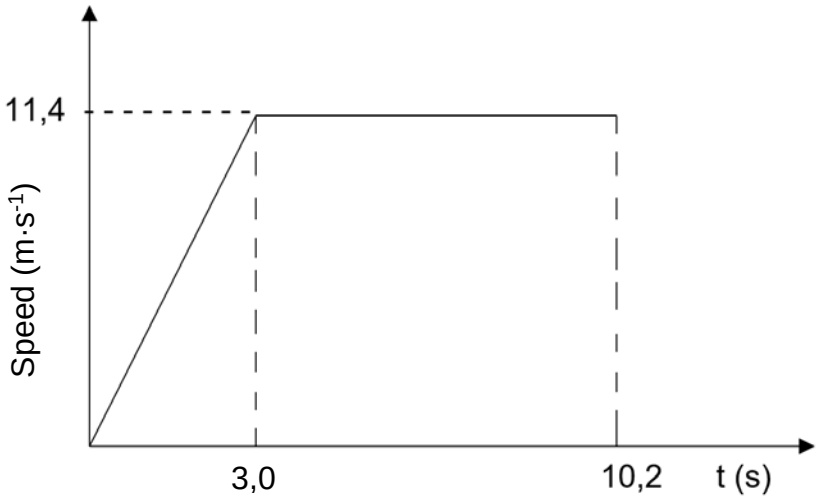
2.1.2 the maximum speed reached if the acceleration was 5,3 $m.s^{-2}$.

(3)

2.1.3 the distance covered by athlete A whilst accelerating.

(3)

Athlete B is taking part in the same race. The following graph shows the speed of athlete B during his race for 10,2 seconds.



2.1.4 Calculate the distance covered by athlete B at the time that athlete A reached his maximum speed.

(4)

2.1.5 During the course of the race both athletes reach the same speed while they are running. Determine the time at which they reach this speed.

(3)

2.1.6 Give the definition of *acceleration* in words.

_____

_____

_____

(2)

2.2 A car, starting from rest, accelerates for 10 s and then travels at a constant velocity of 22 $m.s^{-1}$ along a horizontal road, westwards. The car then starts to decelerate at 2 $m.s^{-2}$ until it stops. It covered a distance of 1,4 km at this time.

2.2.1 (a) Give the definition of *velocity*.

(2)

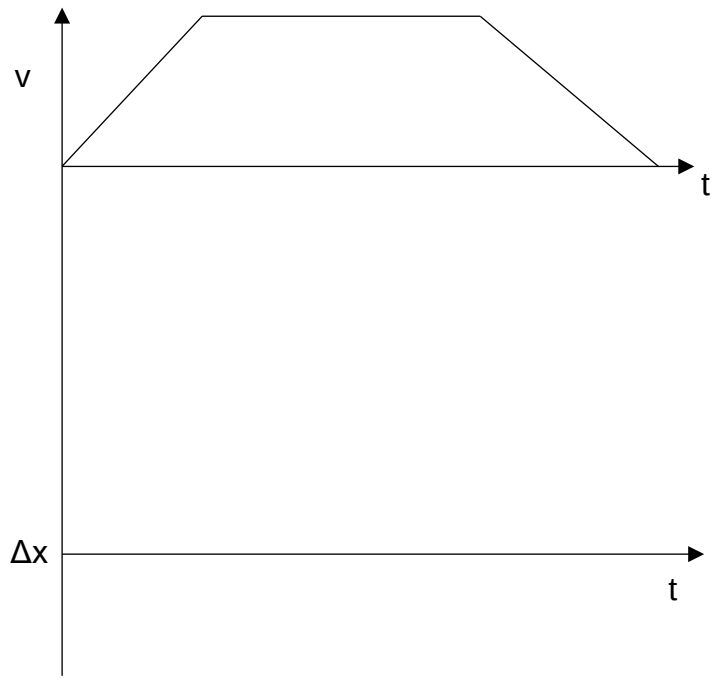
(b) Give the definition of a *distance covered*.

(2)

2.2.2 Calculate the acceleration in the first 10 s.

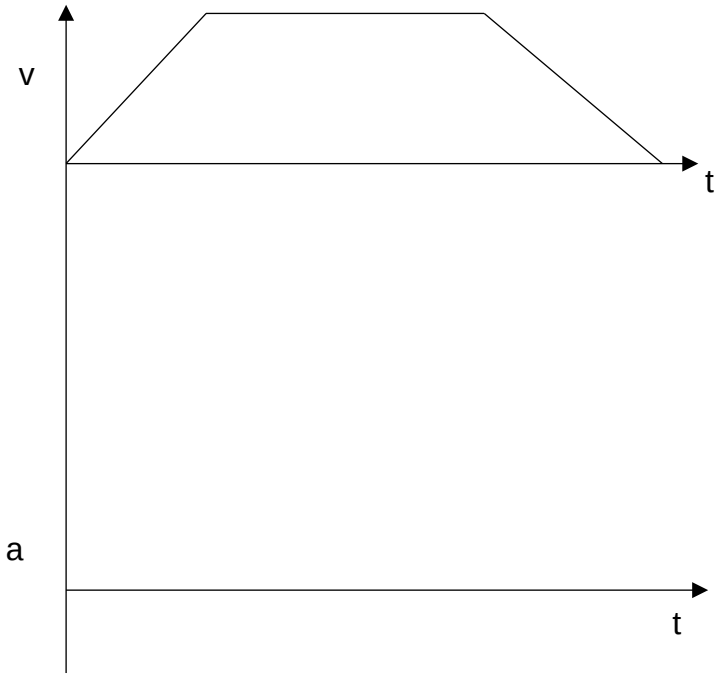
(3)

2.2.3 The following graph shows the velocity-time graph of the movement of the car.
Draw the corresponding displacement-time graph on the axis provided.



(5)

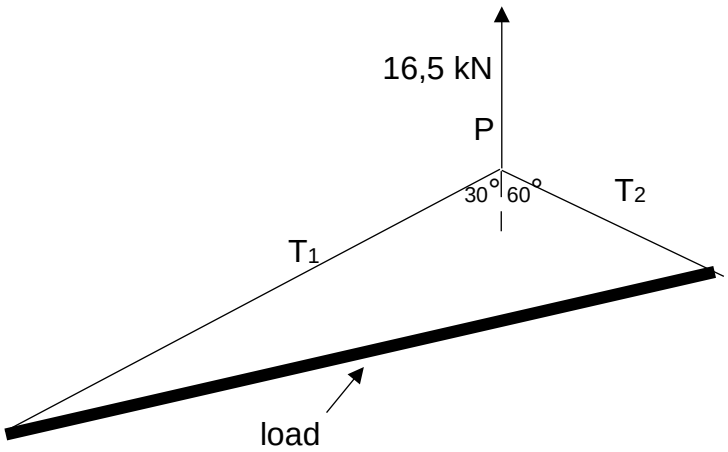
2.2.4 Draw the corresponding acceleration-time graph on the axis provided.



(3)
[33]

QUESTION 3

3.1 The diagram shows a crane lifting a load at constant velocity. The vertical force applied by the crane cable on point P is 16,5 kN and the tensions in the two ropes are T_1 and T_2.

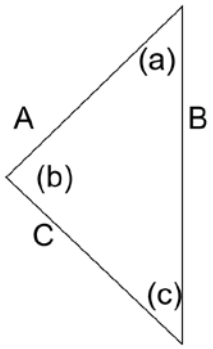


3.1.1 If a **triangle is drawn**, showing all the forces acting on point P, it will look like the sketch given. On the given triangle, draw in the directions of the three forces and identify what force each of A, B and C represents as it correlates to the sketch, as well as the angles (a, b, c) involved.

A _____

B _____

C _____



(a) _____

(b) _____

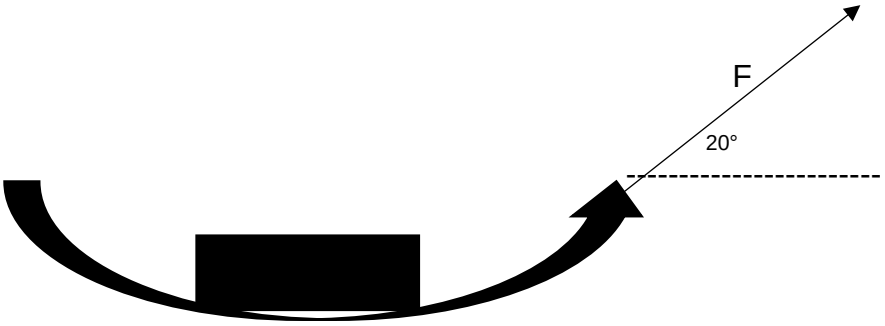
(c) _____

(5)

3.1.2 Calculate the tensions T_1 and T_2, in the SI unit acting in the strings.

(4)

3.2 A heavy sledge, mass 45 kg, is pulled across a snowfield. The diagram shows the direction of the force F exerted on the sledge. Once the sledge is moving, the average **horizontal** force needed to keep it moving at a constant speed over level ground is 250 N.



3.2.1 Calculate the force F that must be applied to the sledge to keep it moving at a constant speed.

(2)

3.2.2 Explain why the work done in pulling the sledge cannot be calculated by multiplying **F** by the distance the sledge is pulled.

(1)

3.2.3 If the sledge was pulled over the snow for 5,0 km and the power used to pull the sledge was 184,75 W, how long, in hours, did it take to cover this distance?

(4)

3.2.4 Explain, with the aid of a calculation of the normal force, why the normal force is not equal to the gravitational force.

(4)
[20]

QUESTION 4

4.1 A flatbed truck carrying a 400 kg concrete block near the back of its flatbed, is travelling due west along a straight level road at 108 $km.h^{-1}$.

The truck collides head on with a concrete bridge support and stops. The concrete block slides into the back of the driver's cab and bends the cab 10 cm inwards before stopping. Assume the friction between the block and the floor of the truck is negligible.

4.1.1 Convert the velocity of the truck into $m.s^{-1}$.

(2)

4.1.2 Consider the stage of motion where the block slides into the back of the cab.

(a) While sliding, what are the forces acting on the block?

(2)

(b) When colliding into the cab, the block stops. Give an explanation why it stops in terms of Newton's Third Law.

(2)

4.1.3 Calculate the force exerted on the block by the cab. (Assume the force remains constant)

(5)

4.1.4 Calculate the time taken for the block to come to rest from the moment it hits the cab.

(2)
[13]

QUESTION 5

5.1 Collisions can be described as elastic or inelastic. Explain what is meant by an inelastic collision.

(2)

5.2 A ball of mass 120 g strikes a stationary cricket bat with a speed of 18 $m.s^{-1}$. The ball is in contact with the bat for 0,14 s and returns along its original path with a speed of 15 $m.s^{-1}$.

Calculate:

5.2.1 the total change in momentum of the ball.

(4)

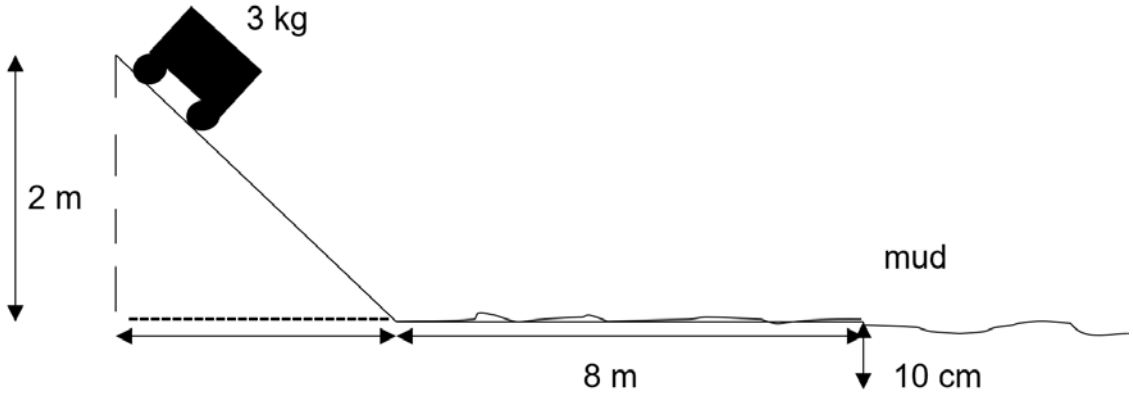
5.2.2 the magnitude of the average force acting on the ball during the collision.

(2)

5.3 The cricket player picks up his bag filled with sports equipment. Its mass is 8 kg. He carries it to his car parked 70 m away. How much work did he do carrying the bag while he was walking to his car? Explain your thinking.

(3)

5.4 A trolley, mass 3 kg, moves from rest down a frictionless incline of height 2 m and reaches the bottom where it moves along a rough horizontal road for 2 s before it falls over the edge into the mud. It sinks into the mud for 10 cm where it stops.



5.4.1 Give the principle of conservation of mechanical energy in words.

(2)

5.4.2 Calculate the speed with which the trolley will reach the bottom of the incline.

(4)

5.4.3 Calculate the speed the trolley will reach just before it leaves the horizontal road to fall into the mud.

(5)

5.4.4 Calculate the work done against friction while the trolley moves through the mud. Accept that the velocity at which it is falling downwards from the ramp is 0, 84 $m.s^{-1}$. Give the final answer to 3 decimal places.

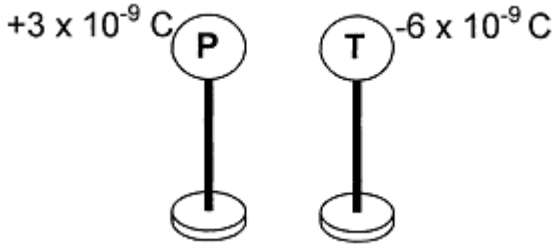
(4)

5.4.5 Calculate the frictional force exerted by the mud to bring the trolley to rest.

(3)
[29]

QUESTION 6

Two metal spheres, P and T, on isolated stands, carry charges of 3×10^{-9} C and -6×10^{-9} C respectively.



The spheres are allowed to touch each other and are then placed 150 cm from each other.

6.1 Calculate the charge on each sphere after they had touched.

(2)

6.2 Did the electrons flow from T to P or from P to T?

(1)

6.3 Calculate the number of electrons that was transferred during contact.

(4)

6.4 A third sphere R, with a charge of -3×10^{-9} C, is placed between the two spheres T and P, 100 cm away from T. Calculate the net force acting on sphere R.

(6)
[13]

QUESTION 7

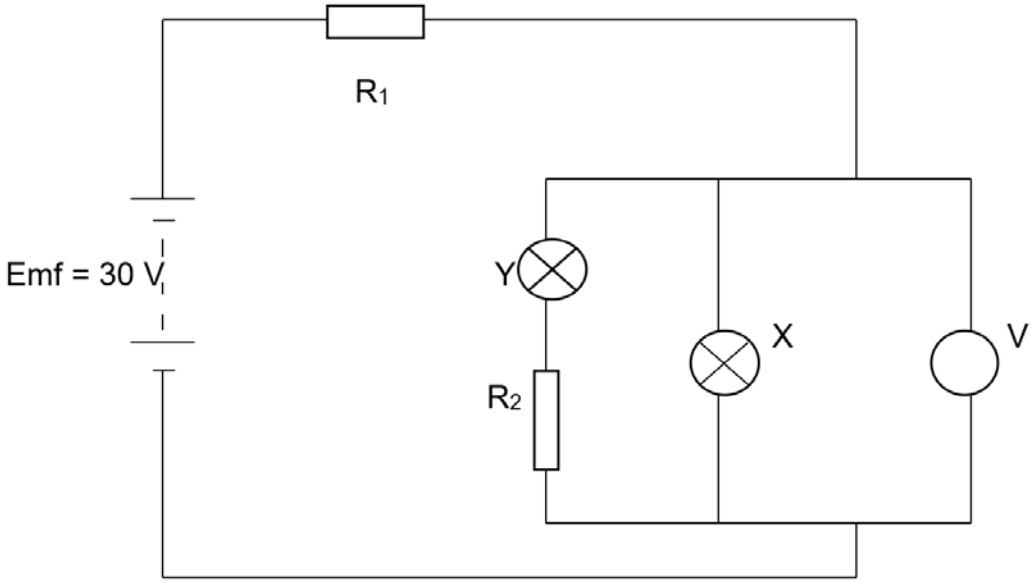
7.1 X and Y are two lamps which have the following ratings when connected as shown in the diagram.

X is rated 18 V; 36 W and
Y is rated 6 V; 18 W.

7.1.1 Calculate the current through each lamp when it operates at the rated voltages.

(4)

The two lamps are connected in the circuit shown below. The battery has an emf of 30 V and negligible internal resistance. The resistors R_1 and R_2 are chosen so that the lamps are operating at their respective rated voltage.



7.1.2 What is the reading on the voltmeter V?

(2)

7.1.3 Calculate the resistance of R_2.

(3)

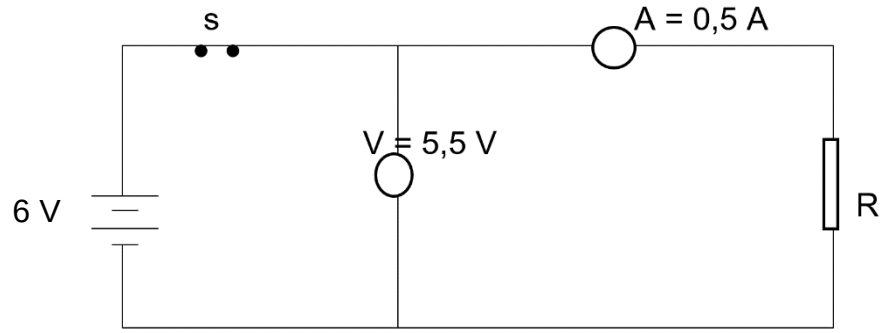
7.1.4 Calculate the potential difference across R_1.

(1)

7.1.5 Calculate the resistance of R_1.

(3)

7.2 Consider the following circuit using a battery with an Emf = 6 V:



V is a voltmeter with a very high resistance and A is an ammeter with a very low resistance. R is a resistor and the readings on the voltmeter and ammeter are respectively 5,5 V and 0,5 A.

7.2.1 Explain why the reading on the voltmeter is different from the emf reading of the battery.

(2)

Calculate:

7.2.2 the resistance R.

(2)

7.2.3 the internal resistance r of the battery.

(3)

7.2.4 the power in R.

(2)

7.2.5 the heat liberated in the battery in 5 minutes.

(3)

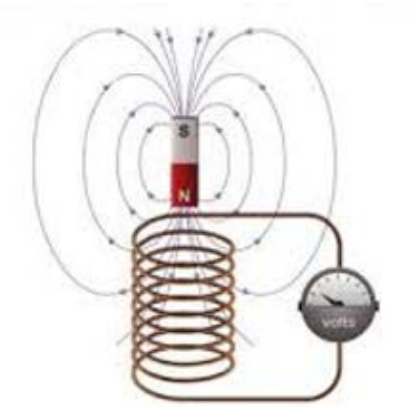
7.2.6 Explain how the reading on the voltmeter V will be affected if the ammeter is replaced by another resistor.

(4)

[29]

QUESTION 8

8.1 A coil is connected to a centre zero ammeter, as shown. A student drops a magnet so that it falls vertically and completely through the coil.



8.1.1 Give Lenz's Law in words.

(2)

8.1.2 Describe what the student would observe on the ammeter as the magnet falls through the coil.

(2)

8.1.3 Explain how electromagnetic induction caused this observation.

(4)

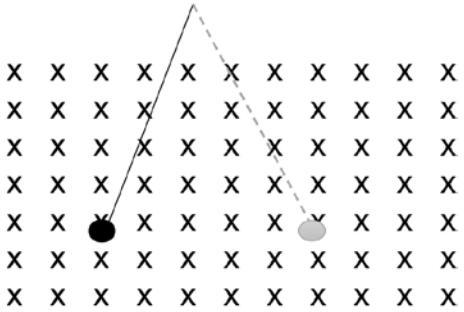
8.1.4 As the magnet falls through the coil, the acceleration decreases a little when entering the coil. Explain why this happens.

(2)

8.1.5 Suppose the student forgot to connect the ammeter to the coil, leaving the circuit open. Describe in terms of the induced emf and current what difference it will make to the acceleration of the magnet.

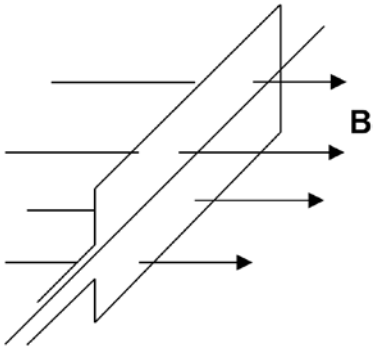
(4)

8.1.6 If a metallic ball on a string swings like a pendulum at a constant speed inside a magnetic field, will there be an emf induced in the ball? Explain your thinking.



(2)

8.2 A wire bent in the form of a rectangle is turned at a constant speed around a horizontal axis. The axis is perpendicular to the magnetic field. The ends of the loop are not connected to anything.



8.2.1 Will there still be an induced emf over the ends of the loop? Explain your answer.

(2)

8.2.2 What will happen inside the coil when the ends are connected to a conductor?

(1)

8.2.3 Explain, with the aid of Faraday's Law, what effect it will have when the loop is turned faster.

(2)

8.2.4 Draw a sketch graph to show the change in emf as the loop turns through one rotation. Start with the loop in the vertical position and show the emf at positions 0°, 90°, 270° and 360° of the rotation.

(3)
[24]

QUESTION 9

9.1 Light is emitted when the vapour of an **element** is bombarded by a high-frequency light. The spectrum of the light emitted contains lines, each of a definite wavelength.

9.1.1 Explain how a high-frequency light can cause the vapour of an element to emit light.

(3)

9.1.2 How does the existence of definite wavelengths in the spectrum of lines support the view that atoms have discrete energy levels?

(1)

9.2 State what is meant by the wave-particle duality of electromagnetic radiation.

(2)

9.3 A metal plate is illuminated by ultraviolet radiation of frequency $1,57 \times 10^{15}$ Hz. The maximum kinetic energy of the liberated electrons is $2,8 \times 10^{-19}$ J.

9.3.1 Calculate the work function of the metal.

(3)

9.3.2 What is the velocity with which the electrons will leave the metal?

(3)

9.3.3 What is the threshold frequency necessary to emit electrons from the metal?

(2)

9.3.4 The radiation is maintained at the same frequency, but the intensity is doubled.

(a) The number of e^- per second released now doubled as well. Explain why that happens.

(2)

(b) Will the maximum kinetic energy also double?

(1)

(c) The metal plate is replaced by another metal plate of a different material. When illuminated by radiation of the same frequency no electrons are emitted.

Explain why this happens.

(2)
[19]

Total: 200 marks

ADDITIONAL SPACE (ALL QUESTIONS)

REMEMBER TO CLEARLY INDICATE AT THE QUESTION THAT YOU USED THE ADDITIONAL SPACE TO ENSURE THAT ALL ANSWERS ARE MARKED.

