NATIONAL SENIOR CERTIFICATE EXAMINATION
SUPPLEMENTARY EXAMINATION MARCH 2016

PHYSICAL SCIENCES: PAPER I

Time: 3 hours 200 marks

PLEASE READ THE FOLLOWING INSTRUCTIONS CAREFULLY

1. This question paper consists of 15 pages, an Answer Sheet of 2 pages and a green Data Sheet of 2 pages (i – ii). 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.

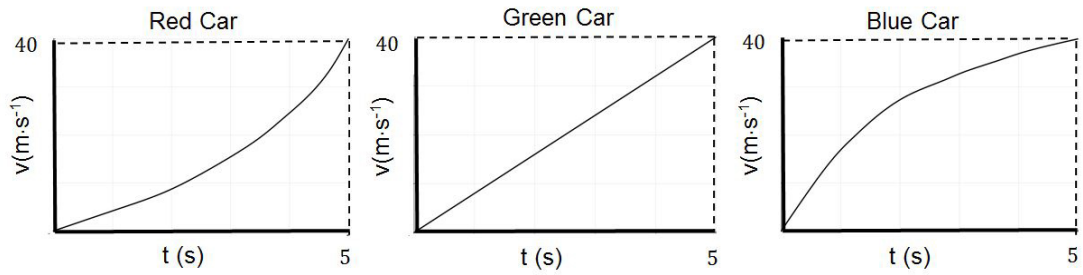
QUESTION 1 MULTIPLE CHOICE

Answer these questions on the Multiple-choice Answer Sheet inside the front cover of your Answer Book. Make a cross (X) in the box corresponding to the letter which you consider to be the most correct.

1.1 Which set consists only of vector quantities?

A mass, acceleration, time
B force, velocity, momentum
C work, charge, potential difference
D power, speed, displacement

1.2 Velocity vs time graphs are shown for three racing cars, a red car, a green car and a blue car. At t = 5 s, which car has travelled the furthest?

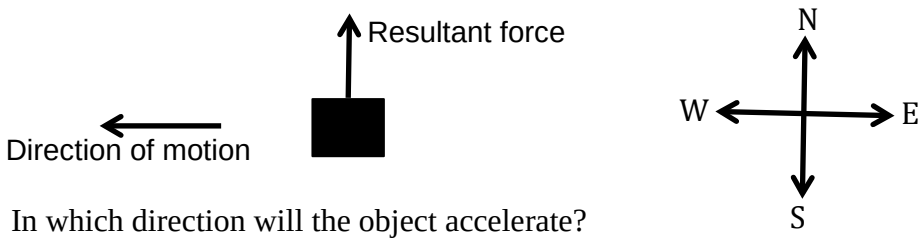


A The red car
B The green car
C The blue car
D All cars travelled the same distance

1.3 You throw a small ball vertically upwards and measure that it takes time $\boldsymbol{t}$ to come back to you. You then throw the same ball upwards so that it takes time $\boldsymbol{2t}$ to come back to you. Which statement is true about the motion of the ball for the second throw?

A The ball's initial speed for the second throw was twice the initial speed for the first throw
B The ball travelled twice as high in the second throw than the original throw
C The ball had double the acceleration on the way up for the second throw
D The ball stopped at the highest point and had zero acceleration at that point

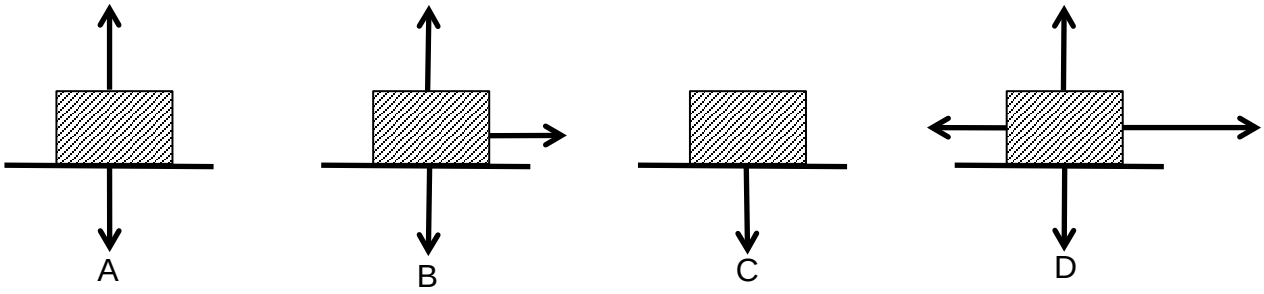
1.4 An object is sliding due west at a constant velocity on a frictionless surface. The object suddenly experiences a resultant force that acts due north.



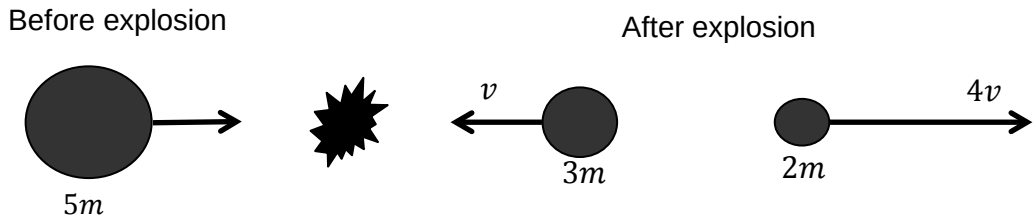
In which direction will the object accelerate?

A North
B West
C North of west, but closer to north than west
D North of west, but closer to west than north

1.5 A block is moving with constant velocity to the right on a frictionless surface. Which sketch below correctly illustrates all the forces acting on the block?



1.6 An asteroid of mass $5m$ is travelling at an unknown velocity. The asteroid explodes into two pieces, one of mass $2m$ with velocity $4v$ and the other of mass $3m$ with velocity v in the directions as shown.



Choose the correct statement and reason that describes the situation.

	Statement	**Reason**
A	$p_{before} = 11\ mv$	Momentum is conserved
B	$p_{before} = 5\ mv$	Kinetic energy is conserved
C	$p_{before} = 11\ mv$	Kinetic energy is conserved
D	$p_{before} = 5\ mv$	Momentum is conserved

1.7 While a motor is in operation, the total power input P_{in} is transferred to useful power output U, and some to wasted power W.

What is the efficiency of the motor?

A $\frac{U}{W} \times 100\%$

B $\frac{W}{P_{in}} \times 100\%$

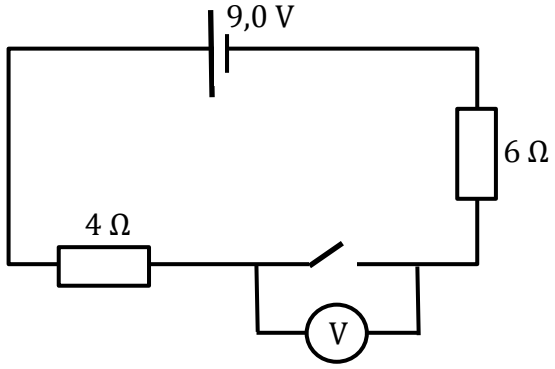
C $\frac{U+W}{P_{in}} \times 100\%$

D $\frac{U}{P_{in}} \times 100\%$

1.8 Two identically charged objects are separated by a distance r. They exert a force F on each other. If you halve the distance between the two charged objects, what will be the new force that the charged objects exert on each other?

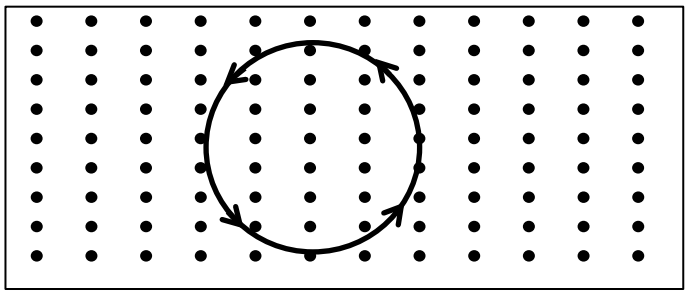
A $2F$
B $\frac{1}{2}F$
C $4F$
D $\frac{1}{4}F$

1.9 A circuit is connected to a 9,0 V emf as shown in the diagram. The switch is open. What will be the reading on the voltmeter?



A 9,0 V
B 0,0 V
C 4,5 V
D 5,4 V

1.10 A single conducting loop is in a region of magnetic field as shown in the diagram. An anticlockwise current is induced in the loop because the magnetic flux is decreasing.



Which of the following changes to the situation would make the induced current larger?

A The magnetic field is increased in magnitude
B Increase the rate at which the magnetic flux is decreasing
C Use a loop with a bigger diameter
D Move the loop sideways, but keep it in the magnetic field

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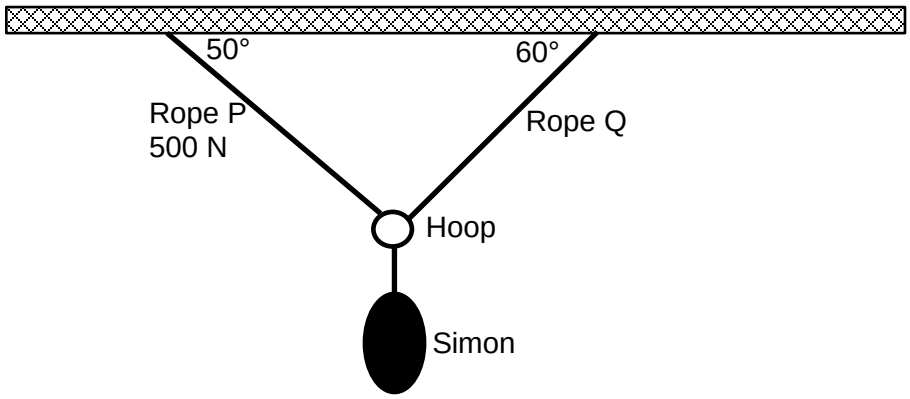
QUESTION 2 ATHLETICS TRAINING

2.1 Simon is hanging at rest from a hoop, which is attached to the ceiling by two ropes. The ropes make angles to the horizontal ceiling of 50° and 60° as shown in the diagram. The tension in the rope P is 500 N.



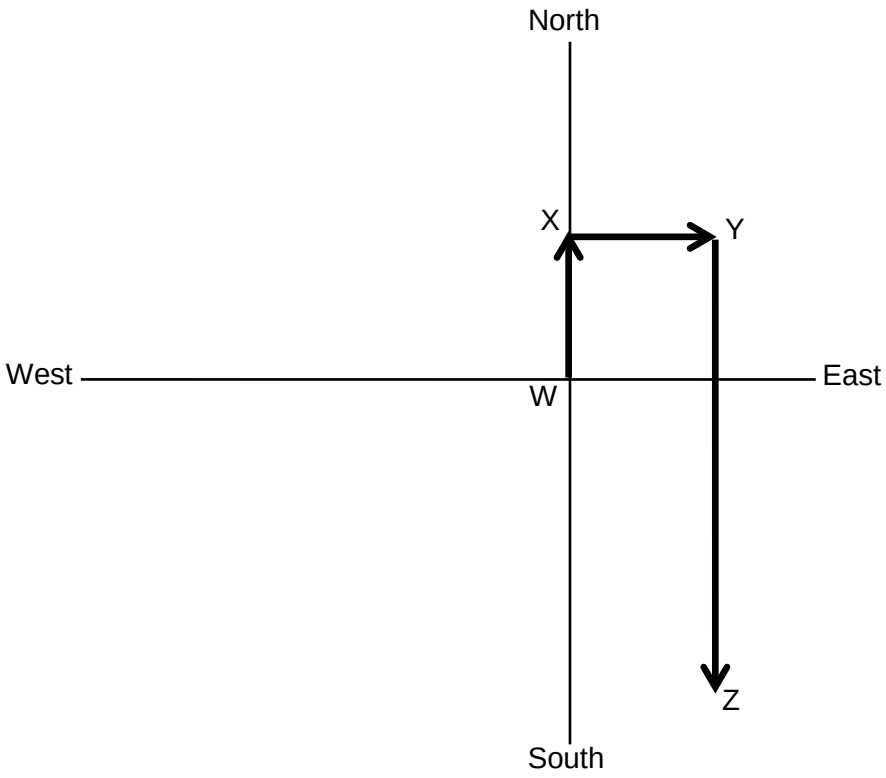
2.1.1 Define a *vector*. (2)

2.1.2 Determine the magnitude of the horizontal component of the tension in rope P. (2)

2.1.3 Calculate the magnitude of the tension in the rope Q. (3)

2.1.4 Determine Simon's mass. (5)

2.2 A sportsman is busy training and is sprinting a marked out pattern on a field. The diagram below shows the path taken by the sportsman. He started the stopwatch at point W. The positions of all the points and the reading on the stopwatch are given in the table after the diagram.



	Stopwatch reading (s)	**Position from W**
W	0	0
X	5	40 m North
Y	10	40 m East, 40 m North
Z	25	40 m East, 80 m South

2.2.1 Define *distance*. (2)

2.2.2 Determine the sportsman's distance for the 25 s illustrated. (2)

2.2.3 Determine the sportsman's displacement for the 25 s illustrated. (5)

2.2.4 Determine the average speed for the sportsman for the 25 s illustrated. (3)
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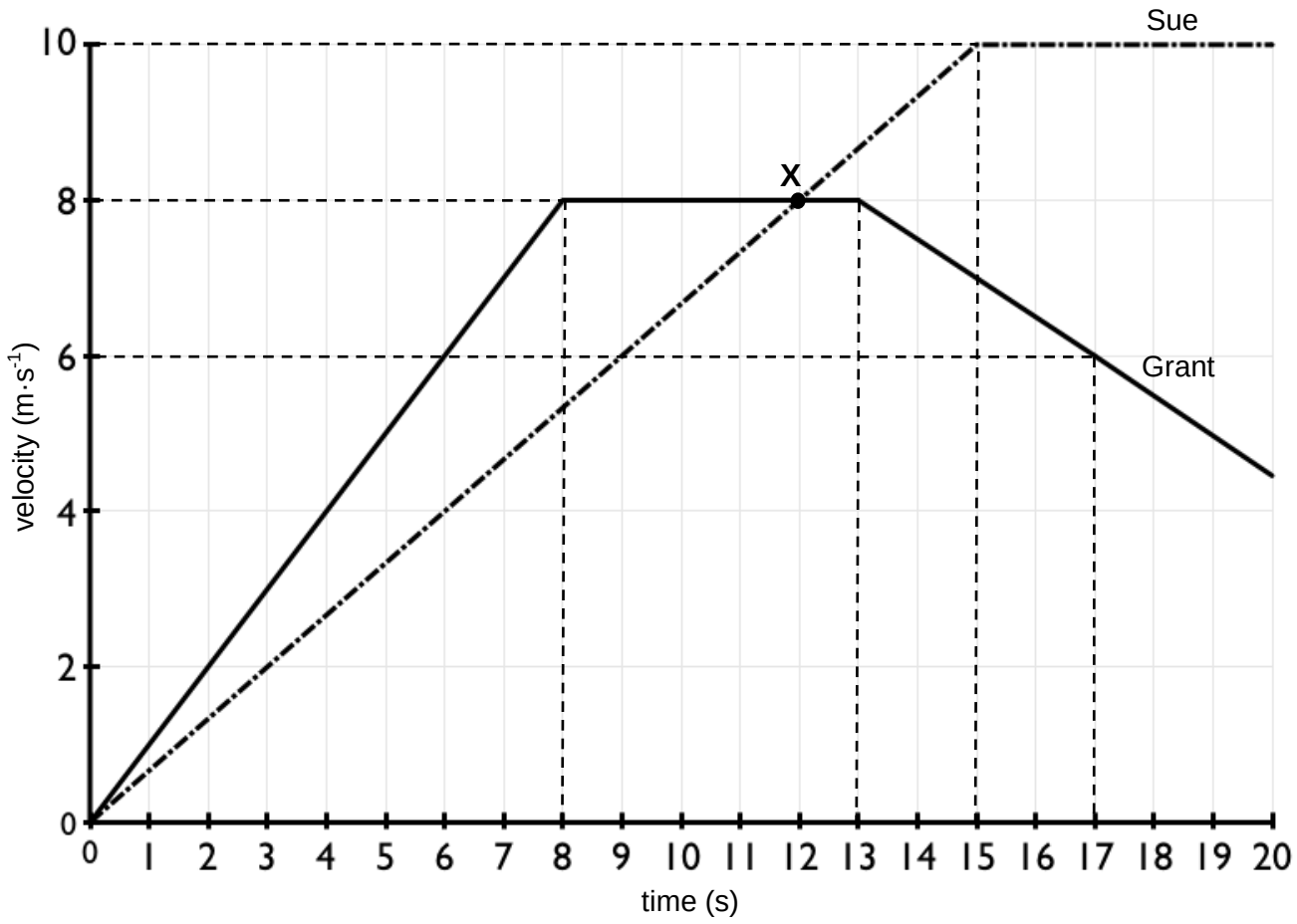
QUESTION 3 RUN AND JUMP

3.1 Two athletes, Grant and Sue, challenge each other to a race over 100 m. The velocity - time graphs for both Sue and Grant running the race are shown.



3.1.1 Define *acceleration*. (2)

3.1.2 Determine the magnitude of Grant's acceleration during the first 8 s of the race. (3)

3.1.3 Describe Grant's motion between 8 s and 13 s. (2)

3.1.4 Determine how far Grant ran in 17 s. (4)

3.1.5 The two graphs intersect at point X. What can you conclude about the athletes at that point? (2)

3.1.6 Determine how long Sue takes to complete the 100 m race. (4)

3.2 The springbok is the national animal of South Africa. It gets its name as the springbok has the ability to jump very high.

[Source: <www.commons.wikimedia.org>]

When a springbok is startled, it crouches down and then pushes on the ground accelerating vertically up at 35 $m \cdot s^{-2}$ for a distance of 0,70 m while it straightens its legs. When the legs are fully straightened, the springbok leaves the ground and rises into the air.

3.2.1 Identify the action-reaction pair of forces involved in the process of the springbok jumping. (2)

3.2.2 Explain why the springbok accelerates upwards even though the forces in Question 3.2.1 are equal. Use one of Newton's laws to help you in your explanation. (4)

Treat the springbok as single particle for the following questions.

3.2.3 At what speed does the springbok leave the ground? (3)

3.2.4 How high above the ground does the springbok jump? (3)

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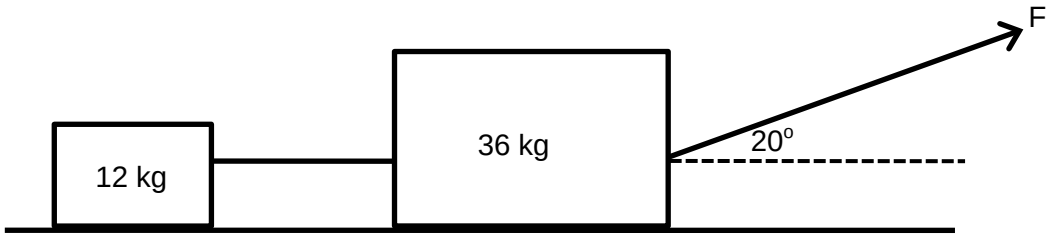
QUESTION 4 BLOCKS

Two blocks are made of the same material. The blocks have masses of 12 kg and 36 kg and are joined together by a light inextensible rope. A force, F, is applied to the 36 kg block at an angle of 20^o to the horizontal as shown. The coefficient of static friction between the surface on which the blocks rest and the blocks is 0,7. The blocks do not slide.



4.1 Calculate the maximum frictional force that could act on the 12 kg block. (3)

4.2 State *Newton's first law*. (2)

4.3 State the magnitude of the tension in the rope joining the blocks when the blocks are about to start sliding. Give a reason for your answer. (2)

4.4 Draw a labelled free-body diagram showing all the forces acting on the 36 kg block. (5)

4.5 Write an expression for the normal force, acting on the 36 kg block. (2)

4.6 Hence, calculate the magnitude of force F when the blocks are just about to start sliding. (4)

[18]

QUESTION 5 ACCIDENTS HAPPEN

5.1 A truck of mass 2 500 kg was being driven at 25 $m \cdot s^{-1}$. Unfortunately, the driver did not see the low overhead bridge and drove straight into the bridge, peeling open the top of his truck. The truck was stopped by the bridge in a distance of 1,8 m.

[Source: <www.bangshift.com>]

5.1.1 Calculate the magnitude of the change in momentum of the truck during the accident. (3)

5.1.2 State the *work-energy theorem*. (2)

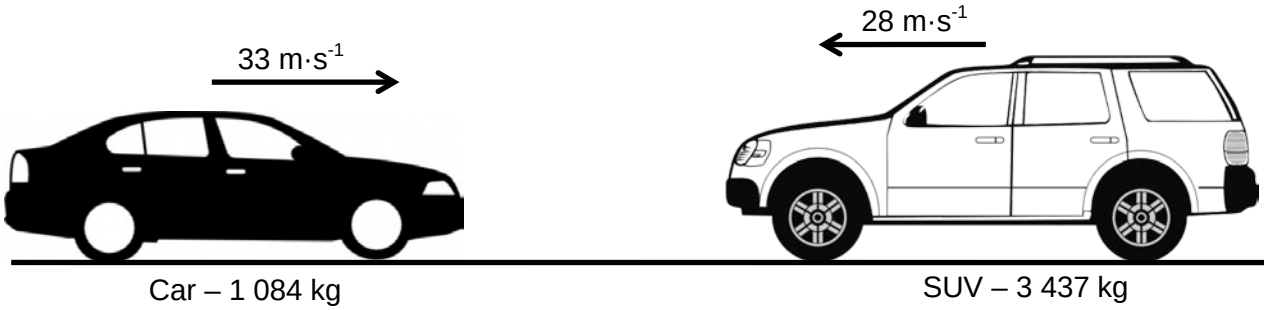
5.1.3 Use the work-energy theorem to calculate the average resultant force that brought the truck to rest. (4)

5.1.4 Use your answers from Questions 5.1.1 and 5.1.3 to calculate how long it took the truck to come to rest. (3)

5.1.5 Fortunately the driver, who was wearing a seatbelt, was not injured during the accident. Explain why the driver would have been more seriously hurt if the same truck had stopped almost instantly. Use a relevant formula to help you in your explanation. (4)

5.2 A small car of mass 1 084 kg was travelling east at a speed of 33 $m \cdot s^{-1}$. A large SUV of mass 3 437 kg was travelling west at a speed of 28 $m \cdot s^{-1}$. The two vehicles collided head on with each other.

Immediately after the collision, the small car was moving west at 5 $m \cdot s^{-1}$.



5.2.1 **Name** the law you would use to calculate the velocity of the SUV immediately after the collision. (2)

5.2.2 Determine the velocity of the SUV immediately after the collision. (5)

5.2.3 Define an *elastic collision*. (2)

5.2.4 Use a calculation to determine if the collision was an elastic collision. (5)
[30]

QUESTION 6 FIELDS

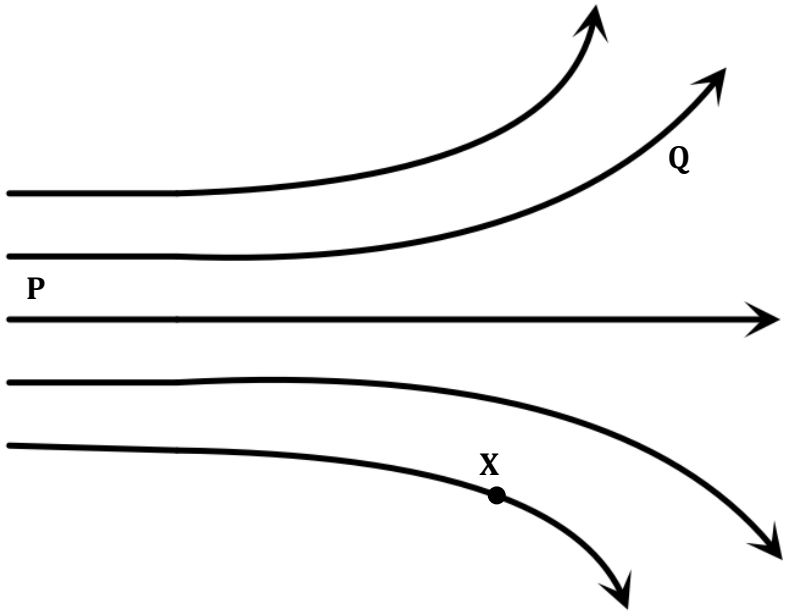
6.1 State *Newton's Law of Universal Gravitation.* (2)

6.2 A dying star of mass $4{,}5 \times 10^{30}$ kg is accelerated towards a black hole of mass $9{,}9 \times 10^{30}$ kg by a gravitational force of $3{,}4 \times 10^{29}$ N.
Calculate the distance between the centres of the black hole and the dying star. (4)

6.3 The acceleration due to gravity on Earth is 9,8 $m \cdot s^{-2}$. The planet Saturn has a mass that is 95 times Earth's mass and a radius that is 9,4 times the Earth's radius. Determine the acceleration due to gravity on Saturn. (4)

6.4 Define *the magnitude of an electric field at a point*. (2)

6.5 The diagram below represents an electric field in a region of space. It can be seen that the field lines are parallel and evenly spaced on the left-hand side and then spread out on the right-hand side.



6.5.1 Compare the strength of the electric field at the positions labelled P and Q. Use evidence from the diagram to explain your answer. (2)

6.5.2 An **electron** is placed at position X as shown. On **the Answer Sheet**, draw an arrow starting on the electron to indicate the force experienced by the electron in the electric field. Label the arrow F. (2)

[16]

QUESTION 7 ELECTRIC CIRCUITS

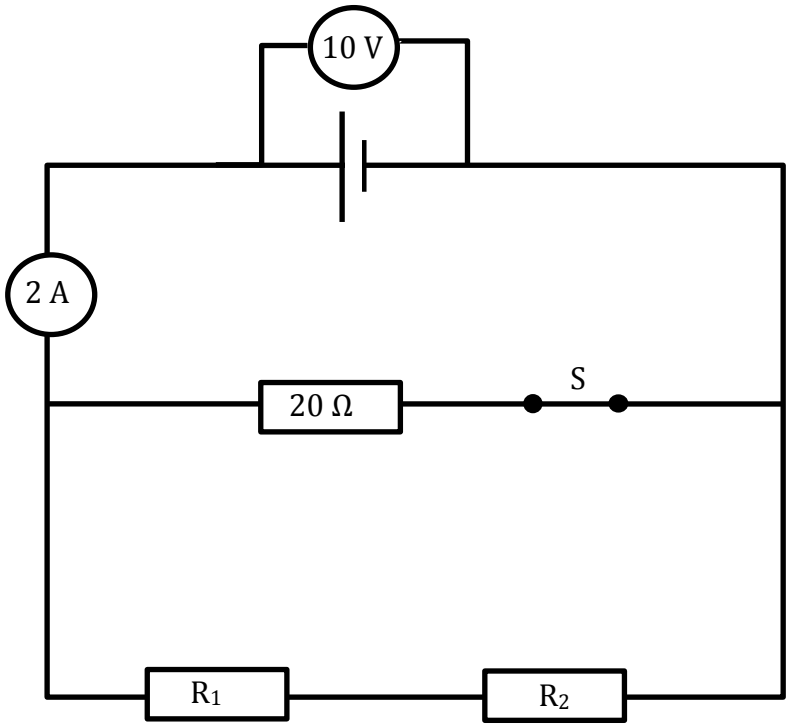
7.1 A battery powers a torch that has a bulb with a resistance of 6 Ω. The potential difference across the bulb is 3 V.

7.1.1 Define potential difference. (2)

7.1.2 Calculate the current in the bulb. (3)

7.1.3 Calculate the amount of charge that passes through the bulb in 10 minutes. (3)

7.2 The circuit illustrated was set up by a group of students. The emf of the battery was 12 V. When the switch, S, was closed, the ammeter read 2 A and the voltmeter read 10 V.



7.2.1 Define *emf*. (2)

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

7.2.3 Calculate the current in the 20 Ω resistor. (3)

The power dissipated in the resistor labelled R_1 is 5,85 W.

7.2.4 Determine the resistance of the resistor labelled R_1. (4)

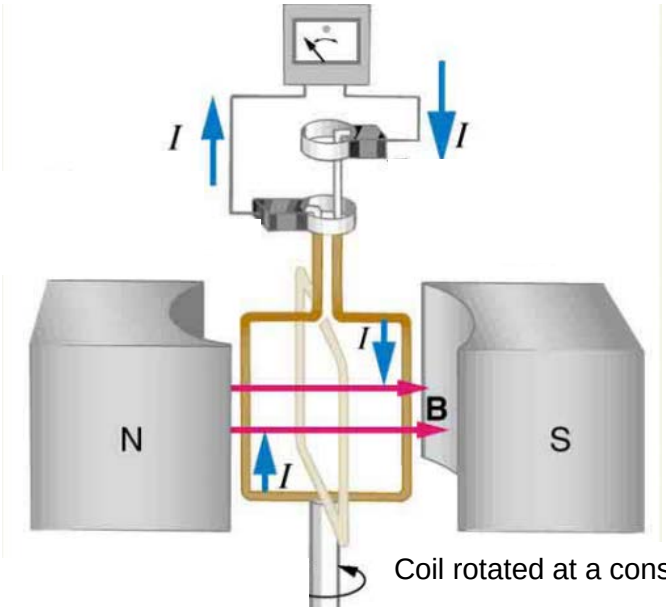
7.2.5 Determine the resistance of resistor R_2. (4)

7.2.6 Will the reading on the voltmeter across the battery increase, decrease or stay the same when the switch, S, is opened? Use an equation to explain your answer. (4)

[28]

QUESTION 8 ELECTRODYNAMICS

Two good physics students decide to conduct an experiment to determine how the magnitude of the induced emf in a homemade generator depends on the number of loops that are wound on the coil in their generator. The students set up an experiment similar to the generator in the diagram below. The students make sure that they turn the generator at the same rate for all of their experiments.



[Source: <https://openstaxcollege.org/files/textbook_version/hi_res_pdf/9/physics-op.pdf>]

The results that the students obtain are recorded in the table below

Number of loops	emf induced (V)
200	0,94
300	1,54
400	1,93
500	2,55
600	3,06
700	3,47

8.1 State the energy conversion that occurs in a generator. (2)

8.2 State a hypothesis for the experiment. (2)

8.3 Name the independent variable for the experiment. (2)

8.4 Name one other variable, besides the rate of rotation, which the students had to keep constant during the experiment to ensure a fair test. (2)

8.5 On the graph paper provided on the **Answer Sheet**, plot a graph of induced emf against the number of loops in the coil. (7)

8.6 Calculate the gradient of the graph. (4)

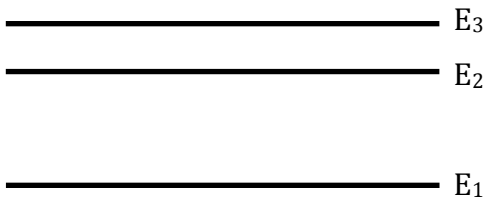
8.7 Use your answer to Question 8.6, your knowledge that $emf = N\frac{\Delta\phi}{\Delta t}$ and that the equation $y = mx + c$ describes a straight line to determine the rate of change of flux during the experiment. (2)

[21]

QUESTION 9 PHOTONS & ELECTRONS

9.1 Describe the photoelectric effect. (2)

9.2 An energy level diagram, for a particular element, is drawn to scale in the diagram below. The only positions that the outer electron can occupy are the energy levels E_1, E_2 and E_3.



9.2.1 How many spectral lines are possible for this element? (2)

9.2.2 Which transition would release light with the highest frequency? (2)

For this energy-level diagram, the longest wavelength possible is 618 nm.

9.2.3 On the diagram, **on the Answer Sheet**, show the transition for this wavelength. (2)

9.2.4 Calculate the energy in joules that corresponds to a wavelength of 618 nm. (4)

9.2.5 Explain why a transition between energy levels produces an emission line. (2)

[14]

Total: 200 marks