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PHYSICAL SCIENCE PAPER I - Physics

PRELIMINARY EXAMINATION 2020

GRADE 12

Examiner: D.R. Raath

Marks: 200

Moderator: R. Goodhead

Time: 3 hours

Please read the following instructions carefully.

1. This examination script consists of 23 pages of which page 22 is an Answer sheet and page 23 is the Graph paper.
2. The Answer sheet and the Graph paper are attached to the front of your Answer book.
3. You are encouraged to make use of the IEB data sheets provided at the end of this examination script.
4. Only non-programmable calculators and appropriate mathematical instruments may be used.
5. Answer all the questions and number your answers **EXACTLY** as the questions are numbered in this script.
6. **Start each question on a new page** and leave a line between each sub – section, i.e.: 1.1 and 1.2.
7. All rough work must be deleted by a diagonal line drawn across your work.
8. You may only write in **BLUE or BLACK pen**. Write legibly.
9. Round off to **two decimal places** unless otherwise stated in the question.

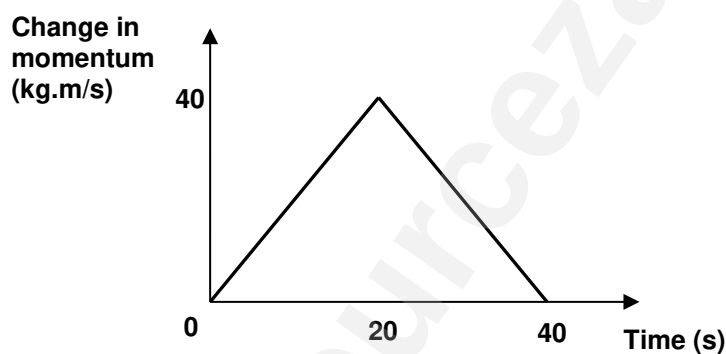
Question 1: Multiple Choice

On your ANSWER SHEET indicate with a cross (X) the letter that corresponds to the correct answer for each of these questions.

- 1.1. A body moving at a constant velocity has kinetic energy **E**, as well as momentum **p**. If the velocity of the body is doubled, which one of the following correctly gives the magnitudes of both kinetic energy and momentum?

	Kinetic Energy	Momentum
A	$2E$	$2p$
B	$4E$	$4p$
C	$4E$	$2p$
D	$2E$	$4p$

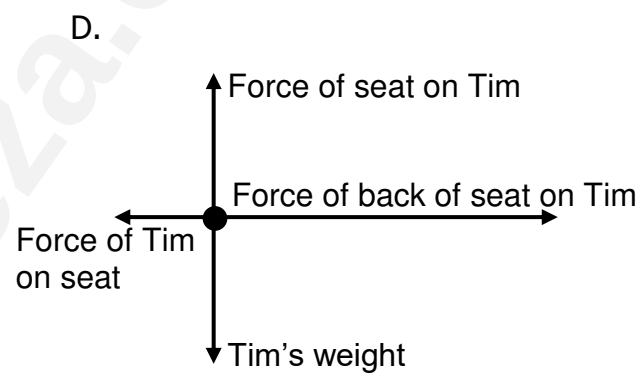
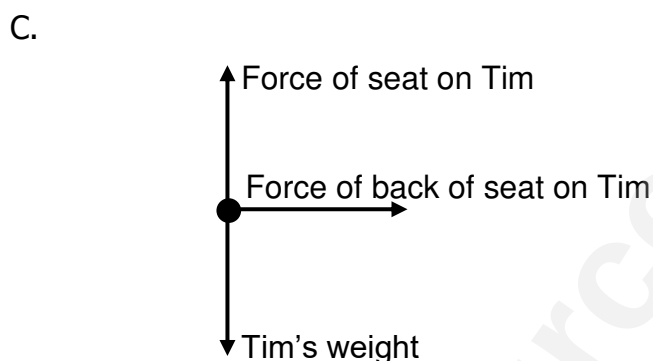
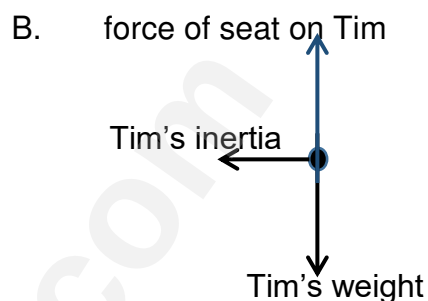
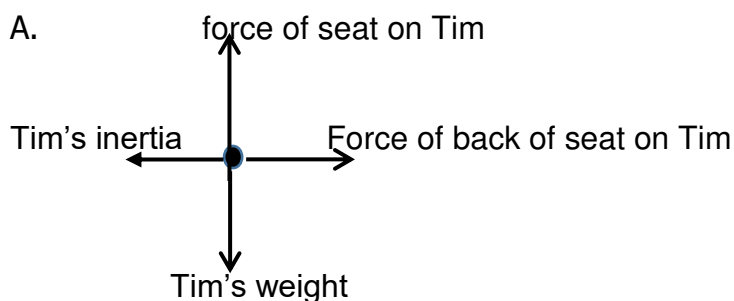
- 1.2. The gradient of the graph below represents....



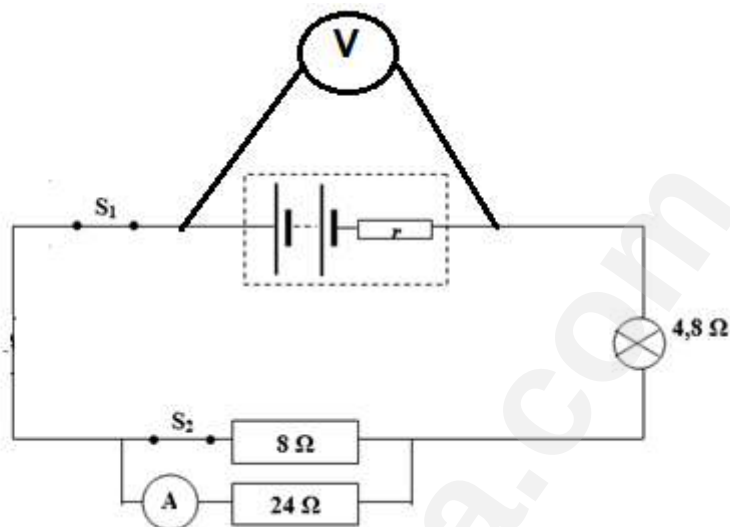
- A. energy
- B. work
- C. displacement
- D. resultant force

- 1.3 Tim is a passenger seated in an aeroplane which is accelerating along the runway before take-off.

Which free body diagram correctly shows the forces that act **on Tim** as the plane accelerates to the right, along the runway.



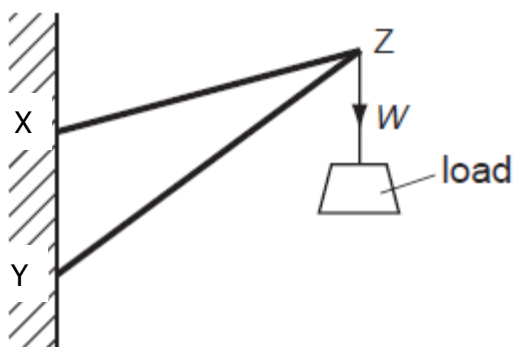
- 1.4 Consider the circuit diagram. Which of the following would describe the ammeter reading and voltmeter reading when S_2 is opened?



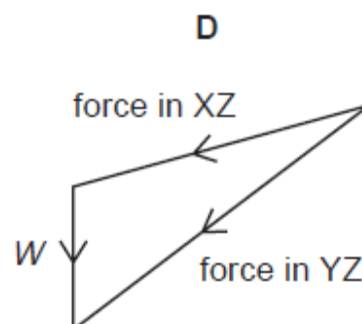
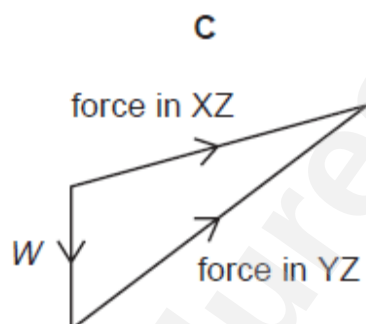
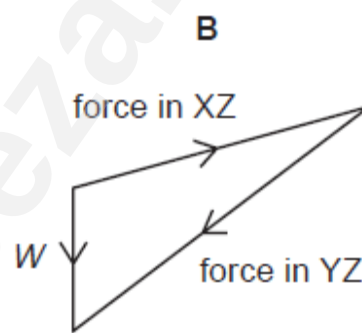
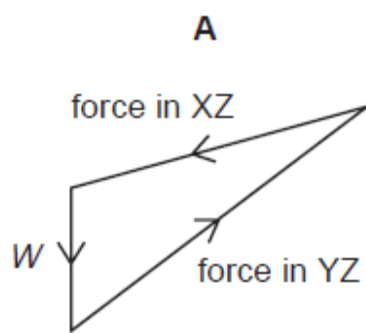
Switch S_2 is open:

	Ammeter	Voltmeter
A.	Decrease	Increase
B.	Increase	Increase
C.	Increase	Decrease
D.	Increase	Increase

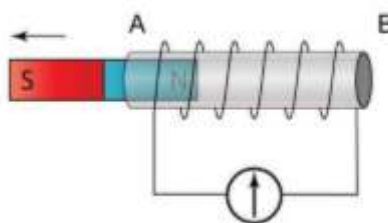
- 1.5 Two rigid rods, XZ and YZ, are fixed to a vertical wall at X and Y. A load of weight W is hung from Z and remains stationary.



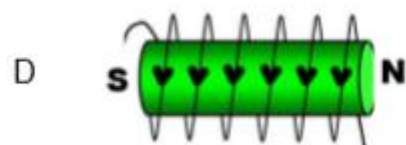
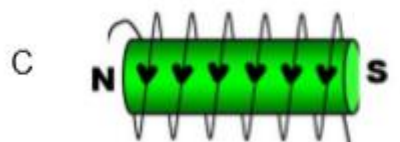
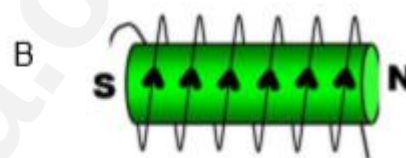
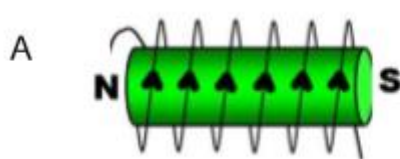
Which diagram shows the forces acting at point Z?



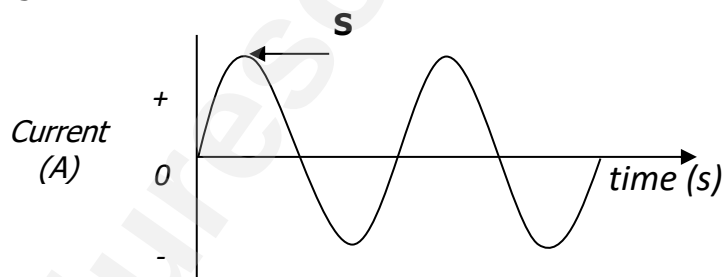
- 1.6 In the diagram below, the magnet is being pulled to the left as shown.



Which of the following correctly shows both the resulting polarity of the solenoid and the current in the coil?



- 1.7 This graph shows the current generated when a generator coil is rotated in a magnetic field.



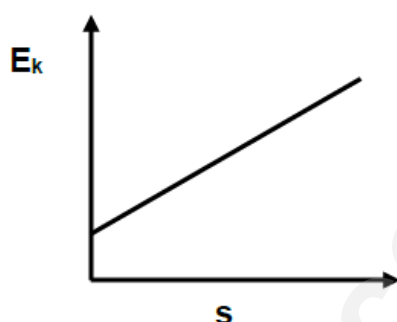
The position of the rotating coil corresponding to point S on the graph above is:

- A. Moving at 45° to the magnetic field
- B. Moving perpendicular to the magnetic field
- C. Moving parallel to the magnetic field
- D. Not moving in the magnetic field

- 1.8 A car travels 50 km at an average speed of 100 km.h^{-1} and then a further 50 km at an average speed of 50 km.h^{-1} . The average speed across the total distance of 100 km is ...

A 55 km.h^{-1}
B 67 km.h^{-1}
C 75 km.h^{-1}
D 60 km.h^{-1}

- 1.9 The graph below shows the kinetic energy (**Ek**) of an object vs. distance. The gradient of the graph represents:



- A the net force acting on the object
B the acceleration of the object
C the momentum of the object
D the power of the object
- 1.10 A 1 kg mass is hanging from a Newton spring balance tied to the ceiling of the lift. The lift is moving down and slows down to come to rest on the ground floor. The acceleration is 2 m.s^{-2} . The reading on the spring balance is ...
- A 9.8 N
B 11.8 N
C 7.8 N
D - 9.8N

[10 x 2 = 20]

Question 2:**(START THIS QUESTION ON A NEW PAGE)**

A flare gun fires a flare high into the air in a situation to let other ships know that you are in distress.

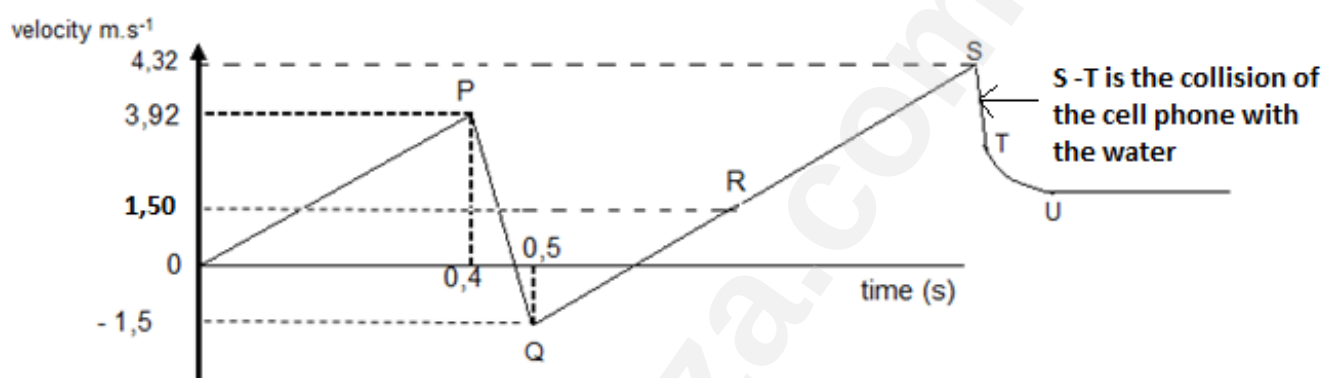
Frank, a sailor, accidentally lets off a flare gun from the deck of a stationary yacht. Frank fires the flare vertically upward and the flare reaches a maximum height of 160 m above the point from where it was fired, before it begins to fall down until it lands in the sea which is 1m below the point the flare was fired. Part of the flare explodes 6 seconds after it was fired. Ignore the effects of air resistance.

- 2.1 Define *acceleration*. (2)
- 2.2 What will be the acceleration of the flare at the maximum height of 160 m? (2)
- 2.3 With what velocity was the flare fired? (4)
- 2.4 At what height above the ship's deck does part of the flare explode? (3)
- 2.5 Draw a sketch graph showing the velocity of the flare with time for the period until the flare landed in the sea. Only include values on the X and Y axis that have already been given or calculated in previous questions. (4)

[15]

Question 3:

Captain Lexi gets such a fright when Frank fires the flare gun that she drops the cell phone that she is holding and it bounces off the deck and into the sea. The graph of the motion of the **cell phone** after she lets go of it is shown below. The collision of the cell phone with the water happens between S and T.

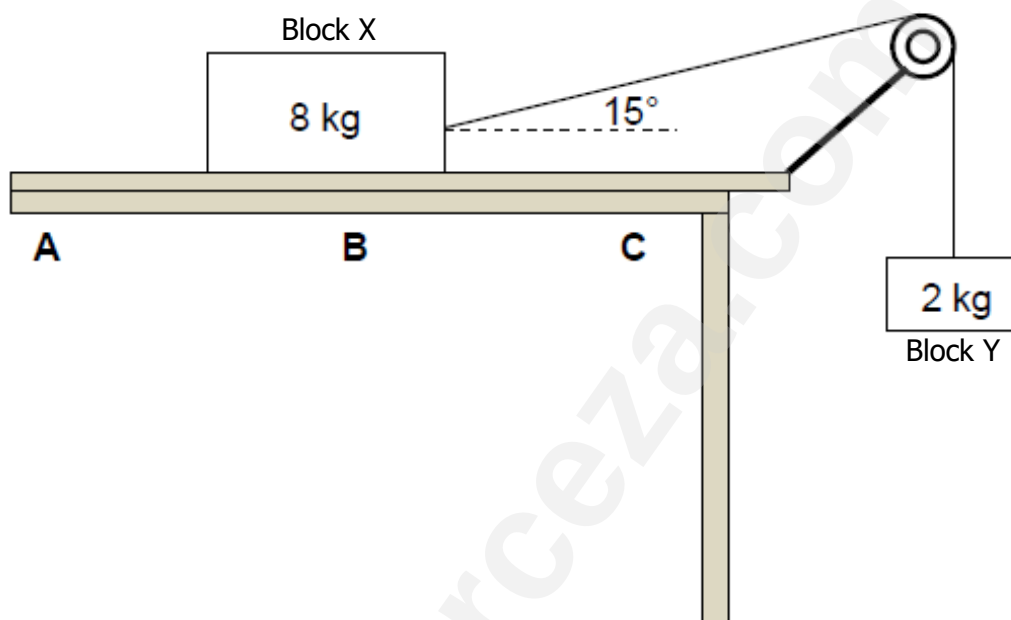


- 3.1 What happens at the point P marked on the graph? (1)
- 3.2 Without using equations of motion determine the height above the deck that the captain was holding his cell phone. (3)
- 3.3 Without using equations of motion determine the acceleration of the cell phone between P and Q. (4)
- 3.4 Draw a graph of displacement vs time for the cell phone from 0 - R. No time value is needed for R and no additional values need to be calculated. Take the deck as zero displacement and make down positive. (4)
- 3.5 At point R on the graph, the cell phone passes the deck. From the information given on the graph how would you know this? (2)
- 3.6 Describe the motion of the cell phone (velocity and acceleration only) **FROM** point R to point S on the graph. (4)
- 3.7 Explain why the graph is curved between T and U and then makes a straight line from U. (3)

[21]

Question 4:

A block, of mass 8 kg, is placed on a rough horizontal surface. The 8 kg block, which is connected to a 2 kg block by means of a light inextensible string passing over a light frictionless pulley, starts sliding from point A to the right, as shown below.

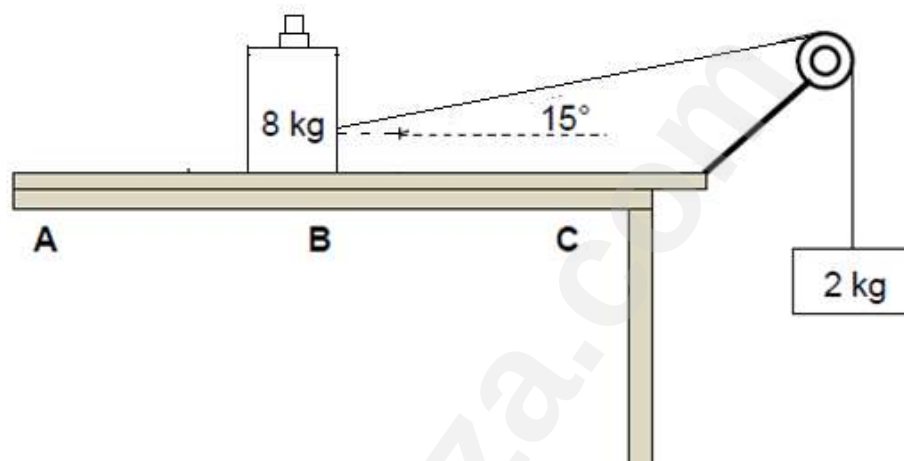


- 4.1 State *Newton's Third Law*. (2)
- 4.2 Identify ONE action reaction pair acting in the diagram above. (2)
- 4.3 When the block reaches point B, the angle between the string and the horizontal is 15° and the acceleration of the system is 1.32 m.s^{-2} .
- 4.3.1 Draw two labelled free body diagrams for the 8 kg block at point B and the 2kg Block. (7)
- 4.3.2 Determine the magnitude of the tension in the string. (3)
- 4.3.3 Calculate the kinetic frictional force between the 8 kg block and the horizontal surface. (4)
- 4.4 As the 8 kg block moves from B to C, the kinetic frictional force between the 8 kg block and the horizontal surface is not constant. Explain why the frictional force changes between B and C. (4)
- 4.5 At point B, the 8kg mass, Block X, is loaded with other masses until Block X just stops moving. If the coefficient of static friction for Block X is 0.25, calculate the new total mass of Block X. (5)

- 4.6 What would happen to the static friction force if the 8 kg block, with same mass pieces on top, was turned over as shown in the diagram below?

Write only increase, decrease or stay the same.

(1)



[28]

Question 5:

- 5.1 The Cassini mission ended in September 2017 when the spacecraft crashed into Saturn's atmosphere.

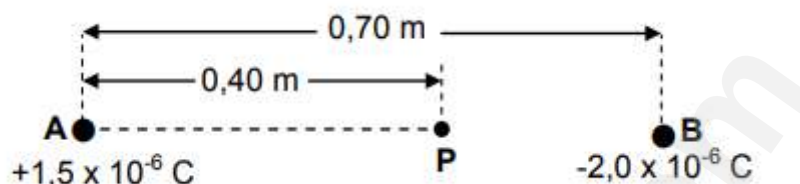
In the last few days of its mission, Cassini flew in and out of the rings of Saturn. At one point the spacecraft, which had a mass of 2 125 kg at the time, was a distance of 140 000 km from the centre of Saturn. Saturn has a mass of 5.6×10^{26} kg.



Image from: www.cbc.ca/news/technology/
CBC News - Posted: Mar 19, 2010

- 5.1.1 State *Newton's Law of Universal Gravitation*. (3)
- 5.1.2 Determine the magnitude of the gravitational force that Cassini experienced from Saturn at this moment. (3)
- 5.1.3 Calculate the gravitational field at this point. (3)

- 5.2 A and B are two small spheres separated by a distance of 0.70 m. Sphere A carries a charge of $+1,5 \times 10^{-6} \text{ C}$ and sphere B carries a charge of $-2,0 \times 10^{-6} \text{ C}$.



P is a point between spheres A and B and is 0,40 m from sphere A, as shown in the diagram above.

- 5.2.1 Define *electric field strength*. (2)
- 5.2.2 Calculate the magnitude of the net electric field strength at point P. (7)
- 5.2.3 A point charge of magnitude $3.0 \times 10^{-9} \text{ C}$ is now placed at point P. Calculate the magnitude of the electrostatic force experienced by this charge. (3)

[21]

Question 6:

It's not just boats that suffer in a whale strike at sea... the consequences for the world's largest known mammal can be every bit as destructive.

Researches off the coast of Mossell Bay have found that almost 15 percent of the whales, which come to the coast to feed every spring, have injuries or scarring consistent with at least one vessel strike. It is estimated that 20 % of whale collisions with large ships result in the death of the whale.

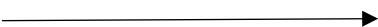
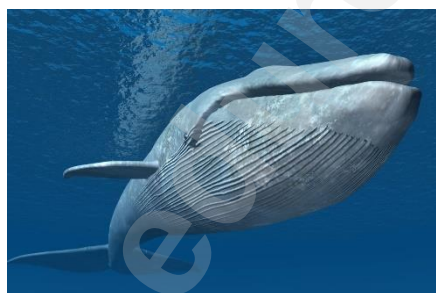


A Steamer is travelling north at 11 m.s^{-1} . The Steamer hits a whale which is travelling south at 5.3 m.s^{-1} and immediately after the collision the steamer's speed changes to 1.1 m.s^{-1} North. The mass of the Steamer is 60 tonnes and the mass of the whale is 30 000 kg.

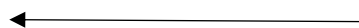
6.1 State the Law of Conservation of Linear Momentum. (2)

6.2 Use the Law of conservation of Linear Momentum to calculate the velocity of the whale after the collision. (5)

On another occasion a yacht of mass 6000 kg travelling west collided head on with a sperm whale of mass 30 000 kg travelling east. The graph below shows the force versus time of a collision of a yacht on a whale.

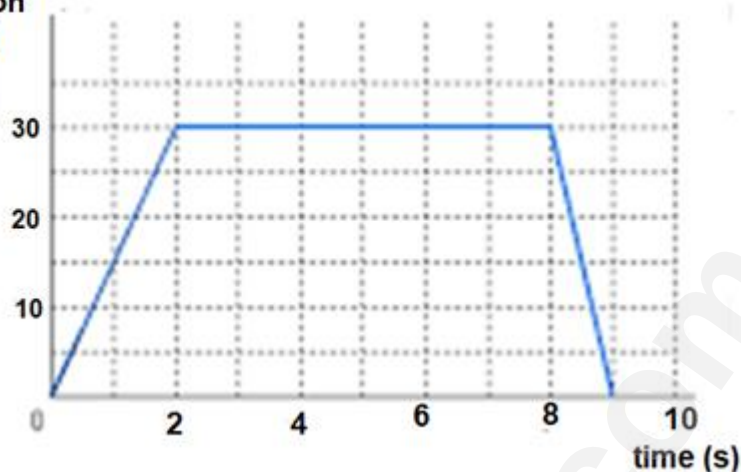


Whale travels East



Yacht travels West

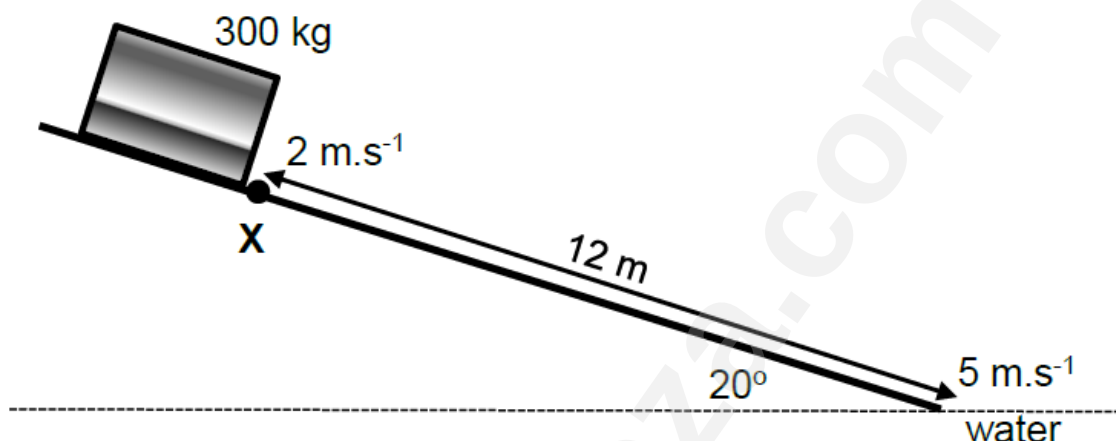
Force of Yacht on
Whale ($\text{N} \times 10^2$)



- 6.3 Define *Impulse*. (2)
- 6.4 Use the graph to find the Impulse of the whale? (4)
- 6.5 What is the impulse of the yacht? (1)
- 6.6 On impact with the whale, the yacht **rebounds** with a velocity of 4.5 m.s^{-1} .
Calculate the initial velocity with which the yacht was travelling before it hit the whale. (4)
- 6.7 Calculate the average net force of the yacht on the whale. (3)
- 6.8 What is the maximum net force on the whale? (2)
- [23]

Question 7:

A box of mass 300 kg slides down the surface of a rough bank inclined at an angle of 20° to the horizontal. It passes point X when moving at 2 m.s^{-1} and slides a further 12 m before entering the water at a speed of 5 m.s^{-1} .



- 7.1 State the work-energy theorem. (2)
- 7.2 Name the conservative and non-conservative forces in the example described in Q 7. (2)
- 7.3 Use energy principles to calculate the magnitude of the friction force acting on the box as it slides down the bank. (6)

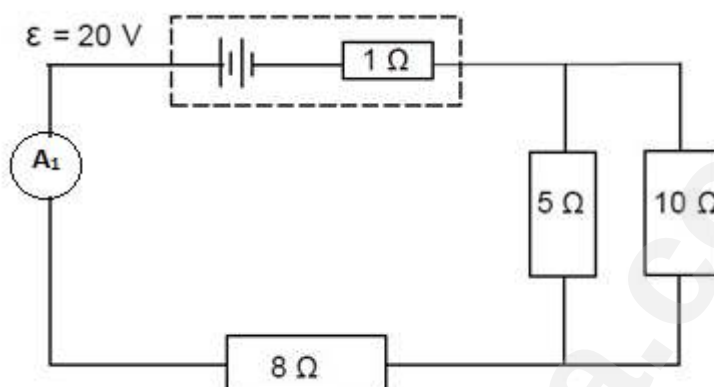
To raise a significantly heavier mass of 950 kg out of the water, a motor is set up. It can raise a 950 kg load with an applied force of 4584.2 N. The velocity at the bottom is 0 m.s^{-1} and at the top the load has a velocity of 4 m.s^{-1} . The friction force between the mass and the slope is 1400 N.

- 7.4 Determine the power output of the motor as it raises the load. (4)

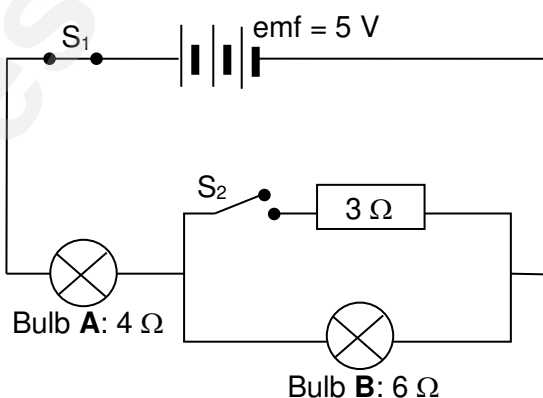
[14]

Question 8:

- 8.1 A battery with an emf of 20 V and an internal potential difference of 1.5 V is connected to three resistors, as shown in the circuit below.



- 8.1.1 Define the term current strength. (2)
- 8.1.2 Calculate the effective resistance of the parallel combination in the circuit. (2)
- 8.1.3 Calculate the current in A_1 . (3)
- 8.1.4 Calculate the **total power** supplied by the battery. (3)
- 8.2 In the circuit shown below the battery has no internal resistance.



When the switch **S_1** , is **closed** and the **S_2** , is **open**, the current through the battery is **0.5 A**.

- 8.2.1 Which bulb, if any, is brighter, **A** or **B**? Explain your answer with reference to suitable calculations. (4)

- 8.2.2 If **BOTH switches are closed**, what happens to the brightness of bulb **A** (*brighter, dimmer or not affected*)? (1)
- 8.3 Calculate the cost of using a 100 W bulb for 3.5 hours at a cost of R1.45 per unit (kWh) (3)

[18]**Question 9:**

The diagram below shows the mechanism of a bicycle dynamo. A dynamo is a small AC generator which is attached to the frame of a bicycle and can be used to power the bicycle light.

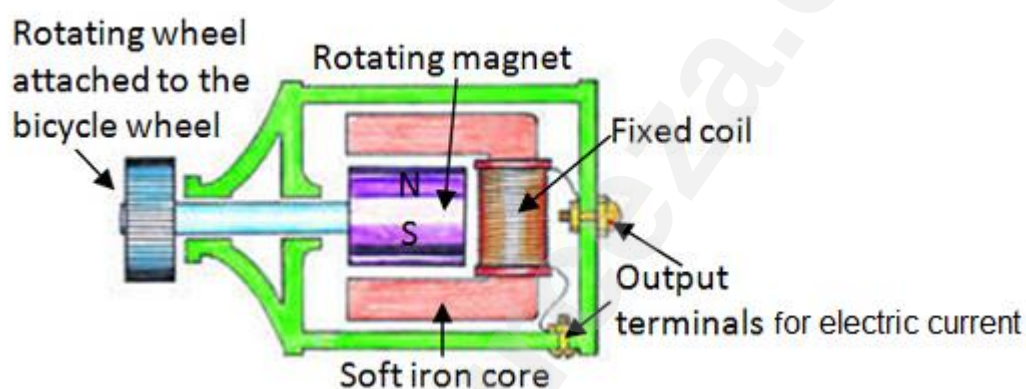
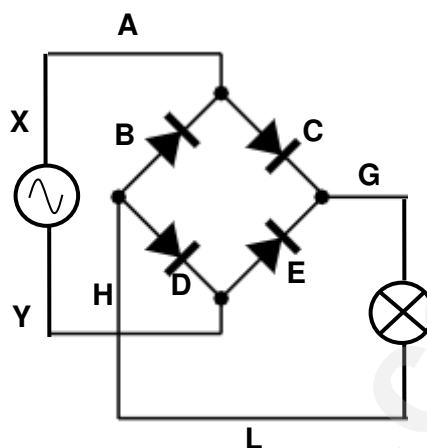


Image: <http://www.excelatphysics.com/ac-generators.html>

The ridged wheel on the left of the diagram touches the rim of the bicycle tyre, turning as the bicycle tyre turns. This wheel is attached to a permanent magnet which is rotated when the bicycle tyre turns. The permanent magnet rotates in the middle of a soft iron core which has a coil of wire around it.

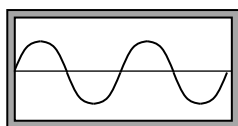
- 9.1 State *Faraday's Law of Electromagnetic Induction*. (2)
- 9.2 With reference to this law, explain how the rotating magnet shown in the diagram above is able to power a bicycle light. (3)

The dynamo generates an alternating current, which charges a battery. A bridge rectifier, as shown below, is used to rectify the current.

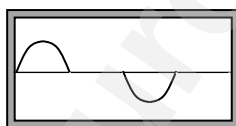


- 9.3 Using the necessary letters shown on the diagram above, indicate the full path taken by conventional current through the circuit when Y is positive. Start with Y. (2)

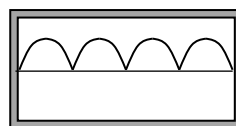
- 9.4 The graphs below show changes in current with time.



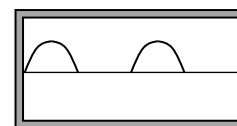
Graph (i)



Graph (ii)



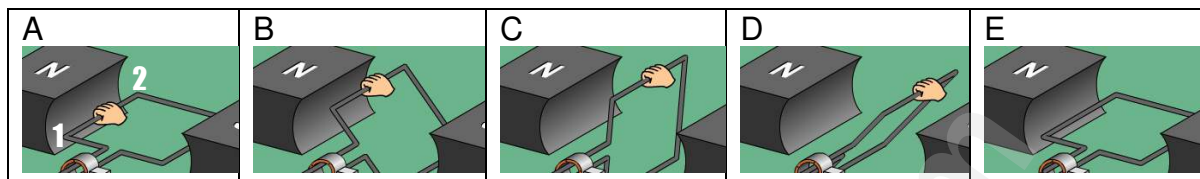
Graph (iii)



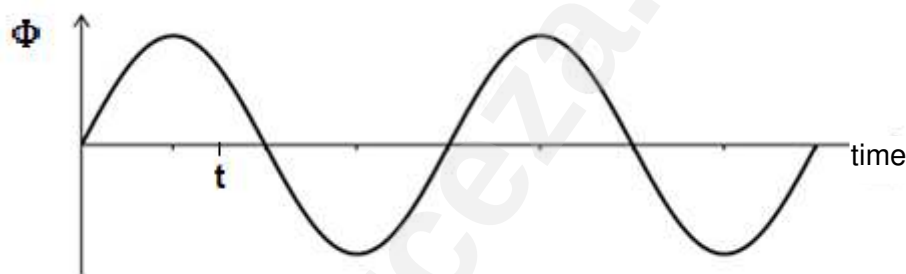
Graph (iv)

Give the number of the graph that shows the current through the lightbulb when it is connected to the generator via the bridge rectifier show above. (1)

- 9.5 Consider a simple generator with a single coil. The sequence of images (A-E) below shows the coil at five possible positions as it is rotated in a clockwise direction in a magnetic field.



A graph showing how the magnetic flux changes over a period of time is shown on the axes below.



- 9.5.1 Consider image A. What is the direction of the conventional current that is induced in the portion of the coil being held by the hand?
Write only 1 to 2 or 2 to 1. (1)
- 9.5.2 Which image (A-E) gives the correct position of the coil at time t on the graph? (1)
- 9.5.3 Based on the graph, how many full rotations (of 360°) did the coil go through? (1)
- 9.5.4 On the axes reproduced on the **answer sheet**, draw in the curve of emf vs time that corresponds to the magnetic flux graph. (2)
- 9.5.5 On the **same set of axes** on the answer sheet, draw in the curve of emf vs time for the output of this generator if the coil is rotated at half the original speed. Clearly label this graph as Q 9.5.5. (2)

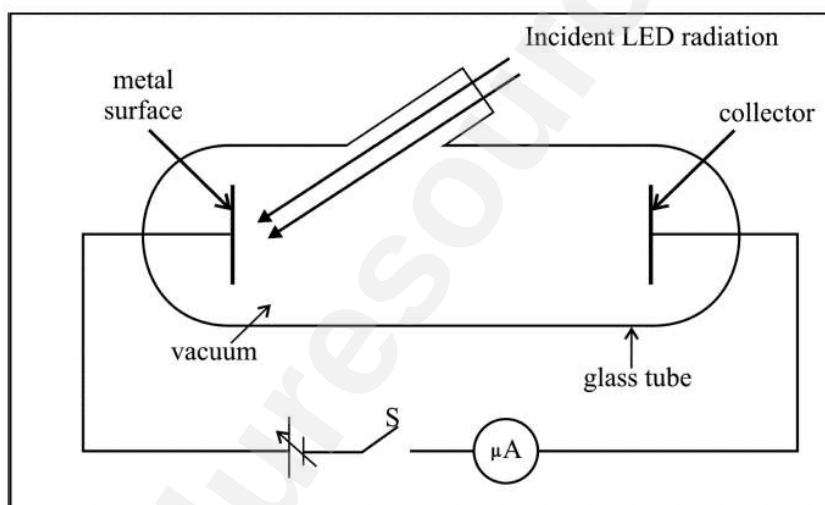
- 9.6 This generator is connected to a transformer where there are 50 turns on the primary coil and 800 turns on the secondary coil. The Emf produced by the generator is averaged out at 3 V. What is the output potential difference of the transformer. (3)

[18]

QUESTION 10

(Adapted IEB Feb 2010)

Sarah wants to conduct an investigation on the photoelectric effect. Her aim is to determine the work function of some metals. She uses the apparatus shown below. She places samples of caesium, potassium and sodium in turn at the metal surface and irradiates them with the light emitted from a variety of LEDs. She closes the switch S and she measures the stopping voltage for each metal under that radiation if there is a reading on the microammeter, by adjusting the voltage until the current stops. The potential difference at which the current stops is called the stopping voltage.



Sarah's incomplete table of results for her **experiment with caesium** is shown below.

Colour/range of incident radiation	Wavelength of incident radiation (nm)	Frequency (Hz) $\times 10^{14}$	Stopping voltage (V)	Maximum kinetic energy of electrons (eV)	Maximum kinetic energy of electrons J ($\times 10^{-20}$)
Green	540	5,56	(b)	0,15	2,43
Blue	470	6,38	0,26	0,26	(c)
Indigo	440	(a)	0,34	0,34	5,44
Violet	410	7,32	0,43	0,43	6,88
Ultraviolet	350	8,57	0,62	0,62	9,92

- 10.1 Determine the values labelled **a**, **b** and **c** in the table.
Show all calculations and give all units. (6)
- 10.2 What is the independent variable in this experiment? (1)
- 10.3 Using the axes on the Answer Sheet, plot a best-fit line graph of **E_k (eV)** versus frequency for caesium. (5)
- 10.4 Use the graph to determine the threshold frequency for caesium. (1)
- 10.5 Using the graph only and using no calculation determine the work function for caesium. (2)
- 10.6 If the ultraviolet light source was replaced with radiation of 9 nm, what effect would you expect to see change on the initial ammeter reading A? Briefly explain your answer. (4)
- 10.7 Explain what would happen in this experiment if the battery source was turned around. (3)
- [22]**

[Total Marks 200]

Answer Sheet:**QUESTION 1**

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

[10 X 2 = 20]

Question 9.5.4 and Question 9.5.5