ST JOSEPH'S INSTITUTION
PRELIMINARY EXAMINATION 2022
(YEAR 4)

CANDIDATE NAME	

CLASS						INDEX NUMBER		

PHYSICS | **6091/02**

Paper 2

12 September 2022

1 hour 45 minutes
(08:00 – 09:45)

READ THESE INSTRUCTIONS FIRST

Write your name, class and index number on the cover page of this Question Paper and all the work you hand in.
Write in dark blue or black pen on both sides of the paper.
You may use a soft pencil for any diagrams or graphs.
Do not use paper clips, highlighters, glue or correction fluid.

Section A
Answer **all** questions on the Question paper.

Section B
Answer **all** questions. Question 12 has a choice of parts to answer.

Candidates are reminded that **all** quantitative answers should include appropriate units.
Candidates are advised to show formulae and all their working in a clear and orderly manner, as more marks are awarded for sound use of Physics than for correct answers.

The number of marks is given in brackets [ ] at the end of each question or part question.

Section A							
Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8

For Examiner's Use	
Section A	/ 50
Section B	/ 30
Total	/ 80

Section A (50 marks)

Answer all questions in this section.

1 Fig. 1.1 shows how the speed of a rocket SpaceX varies with time as it enters the gravitational field of a new Planet Y with negligible atmosphere. SpaceX has a total mass of 1.8 x 10^6 kg. Once it enters the atmosphere of Planet Y, it undergoes free fall for 8.0 s before its engine fires a continuous thrust to bring it to a gentle upright landing on the surface of Planet Y.

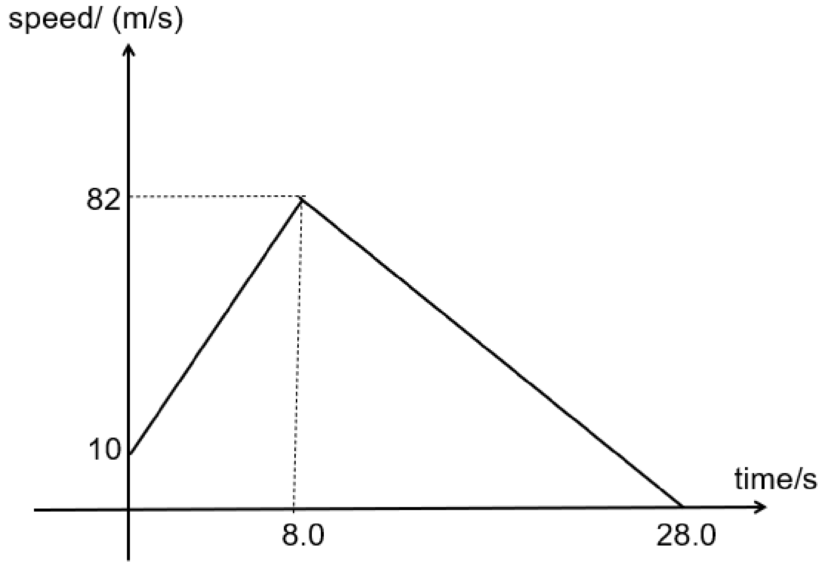


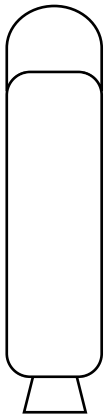
Fig 1.1

(a) Calculate the weight of Space X on Planet Y.

weight = ……………………..[2]

(b) At 8.0 s, significant amount of liquid Oxygen fuel undergoes combustion in the rocket engine to produce a constant thrust,*T* to decrease rocket's speed of descent.

(i) On Fig. 1.2, draw and label all the forces acting on SpaceX during its descent. You may ignore air resistance.



[1]

Fig. 1.2

(ii) Hence, calculate the magnitude of the thrust, *T*.

T = ………………….. [2]

(iii) With reference to the forces acting on SpaceX, explain why the deceleration from t = 8.0 s to t = 28.0 s increases in reality.

Assume that the thrust produced by the engine is uniform throughout the descent.

………………………………………………………………………………………

………………………………………………………………………………………

………………………………………………………………………………………[1]

2 A man in a hot air balloon drops a ping pong ball out of the hot air balloon as the balloon accelerates upwards at 2.0 m/s^2. The speed of the balloon is 2.0 m/s at the moment the ping pong ball is released. Fig. 2.1 shows how the velocities of the hot air balloon and the ping pong ball vary with time.

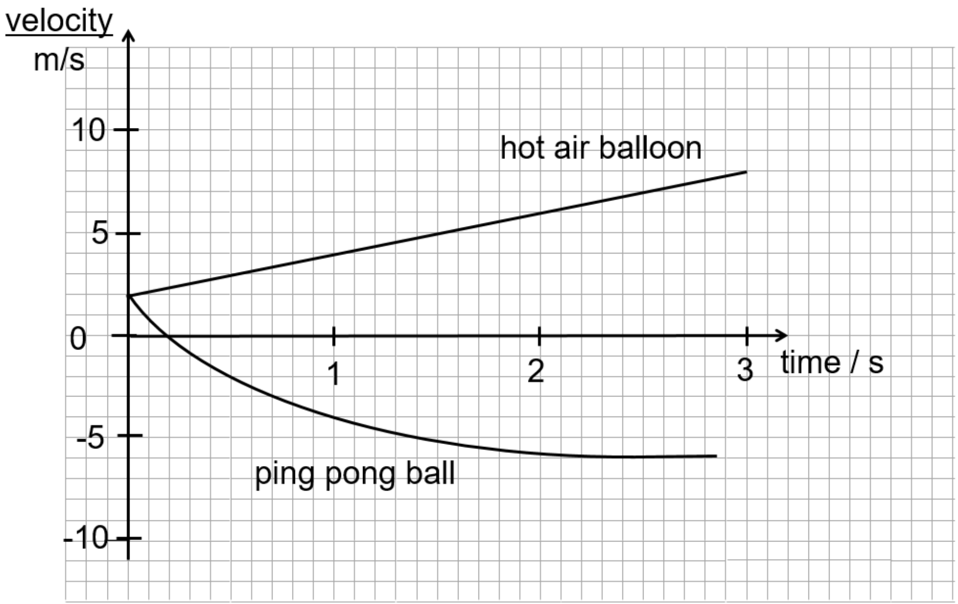


Fig. 2.1

(a) **(i)** Explain why the acceleration of the ping pong ball at its maximum height is 10 m/s^2.

……………………………………………………………………………………………

……………………………………………………………………………………………

……………………………………………………………………………………………[2]

(ii) Describe how the acceleration of the ping pong ball changes from the moment it is released until it reaches terminal velocity.

……………………………………………………………………………………………

……………………………………………………………………………………………

……………………………………………………………………………………………[2]

(b) Calculate the average velocity of the hot air balloon from t = 0 to t = 3.0 s.

average velocity = ………………………………….. [1]

3 Combustion engines in cars work by mixing air and fuel in suitable quantities before the mixture is drawn into a combustion chamber.

Fig. 3.1 shows the side view of a section of a combustion engine in a car. The section of the pipe connected to the fuel tank has a narrower diameter. The pressure of the air flowing into the horizontal section of the pipe decreases as the diameter of the pipe decreases at X.

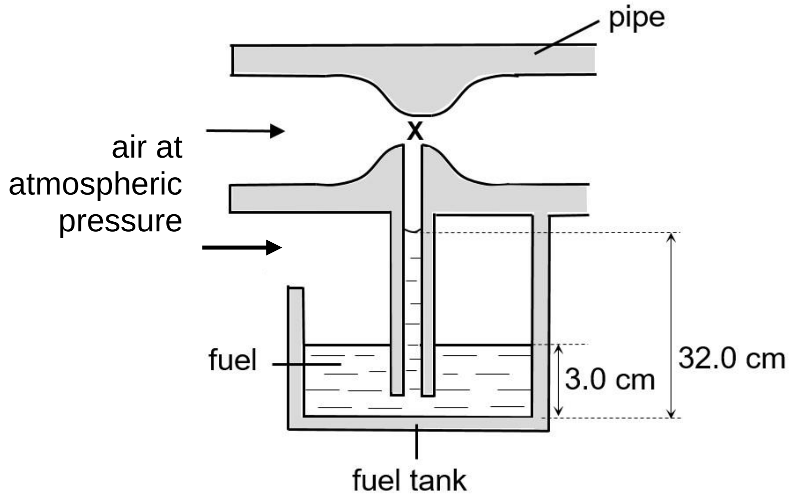


Fig. 3.1

Fig. 3.2 shows a mercury barometer used to measure the atmospheric pressure where the car is located.

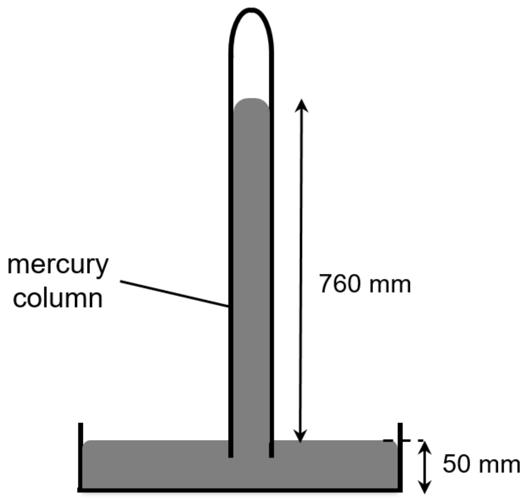


Fig. 3.2

The density of fuel is 850 kg/m^3 and the density of mercury is 13600 kg/m^3.
Take gravitational field strength g to be 10 N/kg.

https://commons.wikimedia.org/wiki/File:Venturi-tube.svg

(a) Explain how Fig. 3.1 shows that the air pressure in the pipe decreases with the diameter of the pipe.

....

....[1]

(b) **(i)** Calculate the value of atmospheric pressure in Pa using Fig. 3.2.

atmospheric pressure = ... [1]

(ii) Hence, determine the gas pressure at point X.

gas pressure = ... [2]

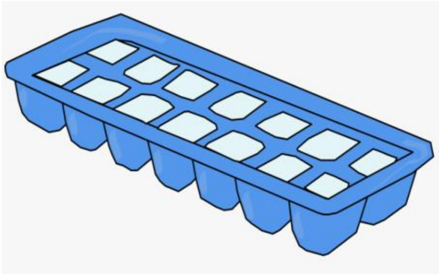
(c) Suggest how the combustion engine makes use of the pressure difference in the different sections of the pipe to mix fuel and air.

....

....

.... [1]

4 A student fills up an ice-cube tray with 200 g of water at 31 ^oC and placed it in the freezer unit of a refrigerator. It takes 20 minutes for the temperature of water in the tray to drop to its freezing point.



Specific heat capacity of water is 4200 J/kg^{o}C and the specific latent heat of fusion of water is 330 kJ/kg. The heat capacity of the ice-cube tray is 120 J/^{o}C.

(a) Calculate the average rate of thermal energy lost by the water and the ice-cube tray as the water cools down from 31 ^oC to its freezing point. Give your answer in Watt.

rate of thermal energy lost = ………………….. [2]

(b) Assuming that the rate of thermal energy lost by the water in the freezer unit is constant, calculate how much additional time is needed for the water in the ice-cube tray to be completely frozen.

time taken = ………………………………. [2]

(c) In reality, the time taken for the water in the ice-cube tray to be completely frozen from its initial temperature of 31^{o}C is longer. Explain why is this so.

………………………………………………………..………………………………

……………………………………………………………………..………………[1]

5 One method of making sandpaper is by passing a roll of paper through nylon friction pads. An aerosol sprays positively charged fine droplets of glue onto the paper, spreading it evenly on the surface of the paper. The resulting sticky paper is then pressed over a flat table covered with sand grains.

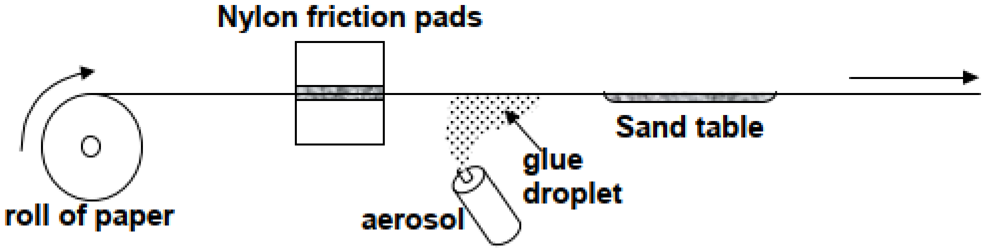


Fig. 5.1

(a) **(i)** Explain how the paper becomes negatively charged after it passes through the nylon friction pads.

……………………………………………………………………………………

……………………………………………………………………………………

……………………………………………………………………………………[1]

(ii) Explain how this method allows the glue droplets to spread out and stick to the paper easily.

……………………………………………………………………………………

……………………………………………………………………………………

……………………………………………………………………………………[2]

(b) Draw in Fig. 5.2 the electric field pattern between two identical glue droplets. [1]

Fig. 5.2

6 A girl lost one of her earrings when she swam in a swimming pool at midnight. She brought a torchlight and shone it into the pool to search for her lost earring. The ray from her torchlight forms a 36^{o} angle with the water surface when the girl finally spotted the earring at the bottom of the pool.

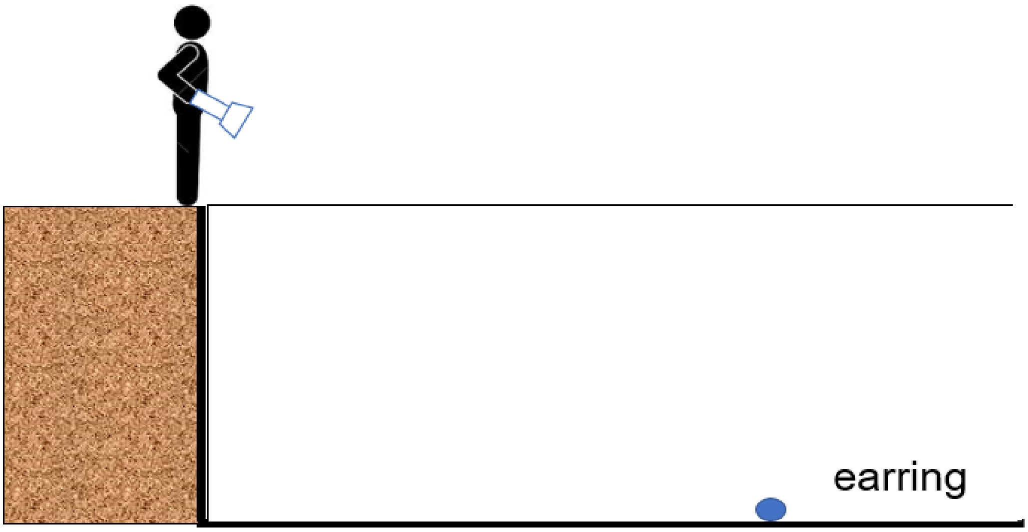


Fig. 6.1

(a) Given that the refractive index of water is 1.3, calculate the angle of refraction of the ray in water.

(i) Calculate the angle of refraction of the ray in water.

angle of refraction = ………………………………. [1]

(ii) Sketch on Fig. 6.1, the path of the ray of light by which the girl is able to see her earring at the bottom of the pool.

Indicate clearly:

- the angle of incident, i
- the angle of refraction, r
- the apparent position of the earring with an 'X' [2]

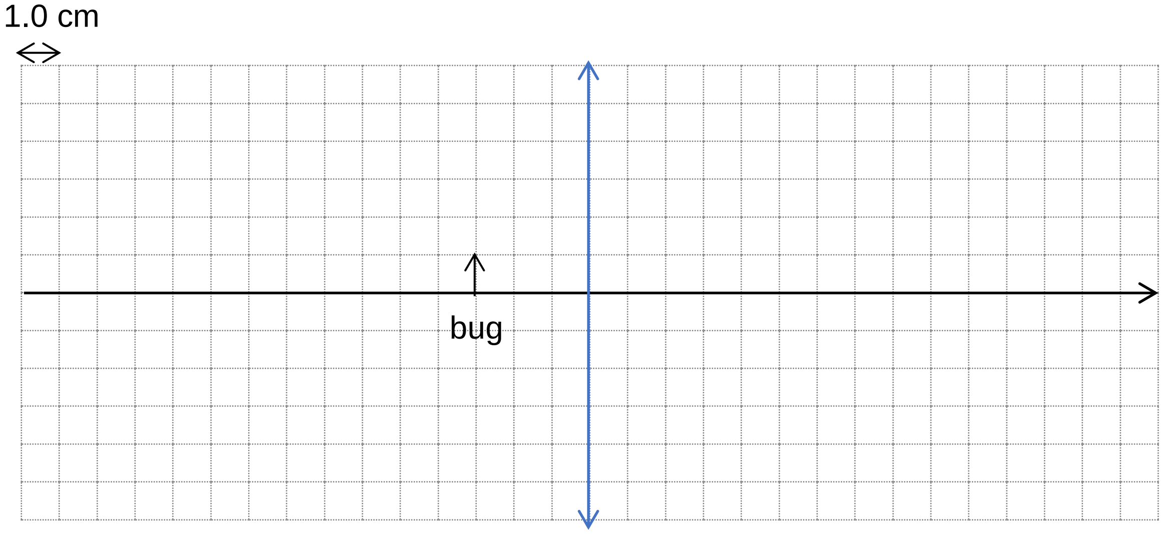
(iii) Explain why no matter where the girl shone her torchlight on the surface of the water, the ray will never undergo total internal reflection.

……………………………………………………………………………………

…………………………………………………………………………………..[1]

(b) As she walked away, the light from her torchlight shone on a bug resting on a wall. The bug was about 1.0 cm long. She placed a magnifying glass 3.0 cm away from the bug to observe it more closely. The magnifying glass gives a magnification of 4.0.

Draw a scaled diagram to determine the focal length of the lens in the space provided below.



[2]

focal length = ………………………….. [1]

7 A heater rated 300 W, 50 V is connected to a 50 V supply by two 100 m long connecting cables made of copper as shown in Fig. 7.1.

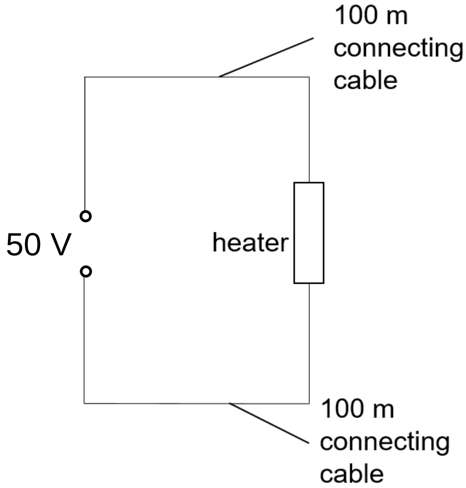


Fig. 7.1

(a) Calculate the resistance of the heater.

resistance = ……………………………… [1]

(b) Given that the resistivity of copper is 1.72×10^{-8} Ω m and the diameter of the wire is 0.734 mm, calculate the total resistance of the connecting cables.

resistance = ……………………………… [2]

(c) Calculate the actual power supplied by the heater in Fig. 7.1 given that its resistance is constant.

power = ……………………………… [2]

(d) The heater in Fig. 7.1 is replaced by a second heater, rated 1000 W, 240 V and connected to the household mains of 240 V.

Show, by means of calculations, why this heater is more efficient compared to the previous heater.

……………………………………………………………………………………….. [2]

(e) The heater is connected to the household mains and an earth wire and a fuse are included for safety reasons.

Describe how the fuse and earth wire protects the user and heater if the metal case of the heater becomes live due to some fault.

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…………………………………………………………………………………………

…………………………………………………………………………………………

……………………………………………………………………………………….. [2]

8 Fig. 8.1 shows the side view of a rectangular coil of wire rotating anticlockwise at constant speed with its axle at right angles to a uniform magnetic field at a particular instant in time.

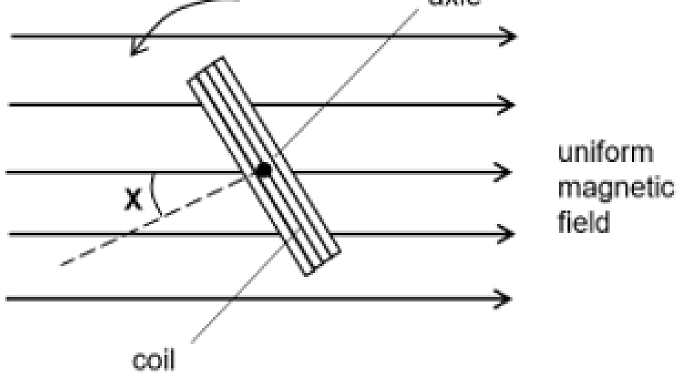

Fig. 8.1

(a) Explain why an electromotive force is induced across the coil of wire.

…………………………………………………………………………………………………..

…………………………………………………………………………………………………..

………………………………………………………………………………………….. [1]

(b) State the smallest angle X such that the magnitude of the induced emf has a maximum value.

………………………………………………………………………………………….. [1]

(c) The output terminals of the coil of wire is connected to a C.R.O via a pair of slip rings as shown in Fig.8.2.

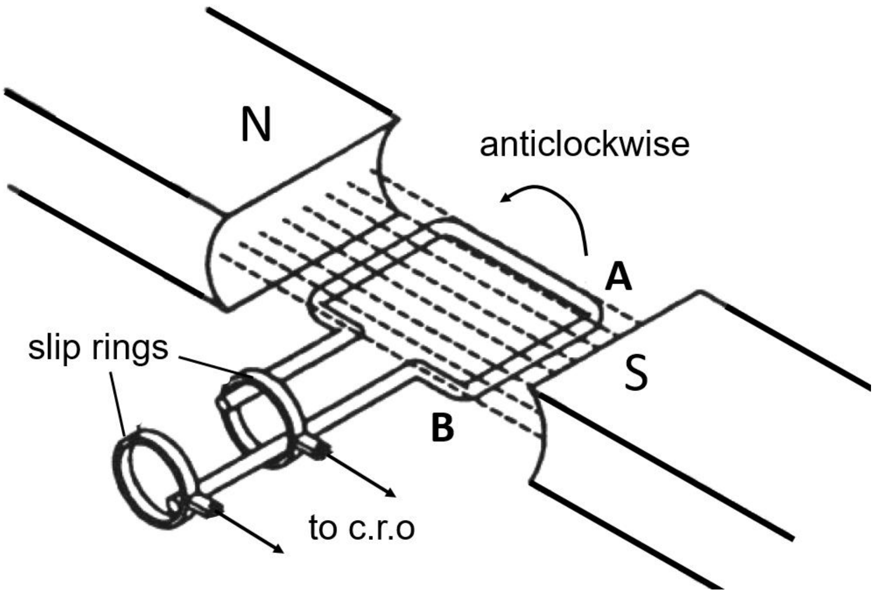

Fig. 8.2

(i) Explain the function of the slip rings.

…………………………………………………………………………………………

……………………………………………………………………………………… [1]

(ii) Draw an arrow on side AB of the coil in Fig. 8.2 to indicate the direction of the induced current in AB. [1]

(iii) Explain how the induced current opposes the change that caused it.

…………………………………………………………………………………………

…………………………………………………………………………………………

……………………………………………………………………………………… [1]

(iv) The position of the coil in Fig. 8.2 is adjusted and set into rotation such that the trace in Fig. 8.3 is observed on the c.r.o. screen.

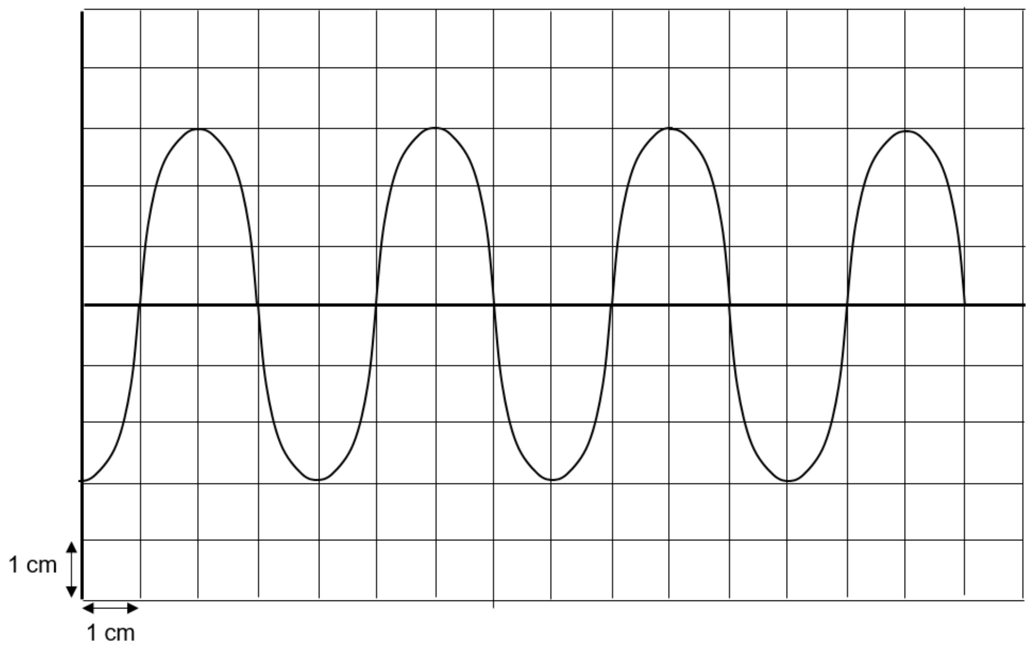

Fig. 8.3

(1) Determine the frequency of the induced emf given that the time-base setting is 10 ms/cm.

frequency = ………………………………… [2]

(2) Draw on Fig. 8.3, a possible trace obtained if the coil is turned through 90º before it is set into rotation and at half the speed. [2]

END OF SECTION A

CANDIDATE NAME	

CLASS						INDEX NUMBER		

Section B			
Q9	**Q10**	**Q11E**	**Q11O**

Section B (30 marks)
Answer all questions in this section.
Answer only one of two alternative questions in **Question 11**.

9 A lorry crane as shown in Fig. 9.1 is used in a construction site to lift concrete beams. The boom is pivoted onto the lorry such that the distance from the pivot point of the boom to the lorry's back wheel is 2.0 m.

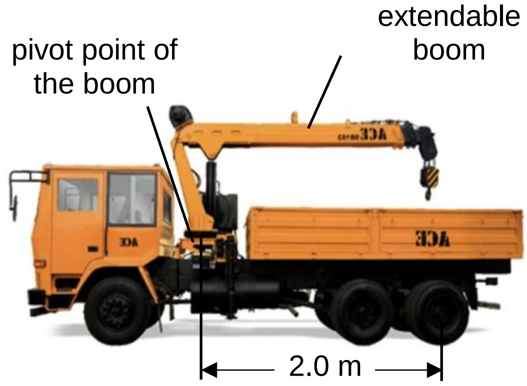

Fig. 9.1

http://www.acecrane.in/sb-163-lorry-loader-crane-4561877.html

Table 9.1 summarises the maximum load that the lorry crane can carry and the corresponding distances from the load to the lorry's back wheel when the boom is horizontal.

Table 9.1

length of boom / m	*distance from the load to the lorry's back wheel / m*	*maximum load / kg*
4.0	2.0	3000
6.0	4.0	1500
8.0	6.0	1000
10.0	8.0	750
12.0	10.0	600

(a) Using the data from Table 9.1, state and explain the relationship between the distance from the load to the lorry's back wheel and the maximum load that the lorry crane can carry.

……………………………………………………………………………………………..

……………………………………………………………………………………….…..[2]

(b) The weight of the uniform boom is 10 000 N.

(i) Calculate the minimum weight of the lorry. Assuming that the distance from the centre of gravity of the lorry to the lorry's back wheel is 2.5 m.

weight = ... [2]

(ii) The actual weight of the boom is much heavier than 10 000 N. Explain why when the length of the boom is 4.0 m, the maximum load that can be lifted is the same as the maximum load shown in Table 9.1.

……………………………..……………………………………………………………..

………………...………..………………………………………………………….…..[1]

(c) Lorry cranes have additional support extended sideways as shown in Fig. 9.2.

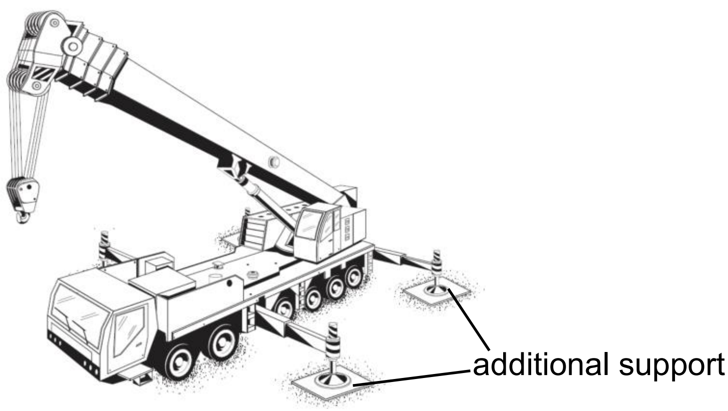

Fig. 9.2

https://www.cranes.org.nz/uploads/2/0/5/7/20572552/crane_stability_and_ground_pressure.pdf

Explain how the additional support increases the stability of the lorry crane.

……………………………………………………………………………………………..

……………………………………………………………………………………….…..[1]

(d) The concrete beam is freely suspended as shown in Fig. 9.3.

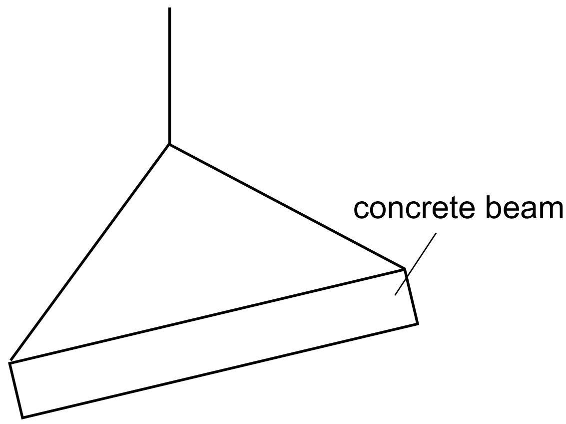

Fig. 9.3

(i) Mark the centre of gravity of the concrete beam with the letter ‘x’. Explain your answer.

……………………………………………………………………………………

……………………………………………………………………………………

…………………………………………………………………………….....[2]

(ii) The concrete beam is made of 10% steel and 90% concrete by volume. If the density of steel and concrete is 7800 kg/m^3 and 2400 kg/m^3 respectively, determine the average density of the beam.

average density = ... [2]

10 Fig. 10.1 shows a solenoid that is connected to a battery such that a north pole is induced at the right end of the solenoid.

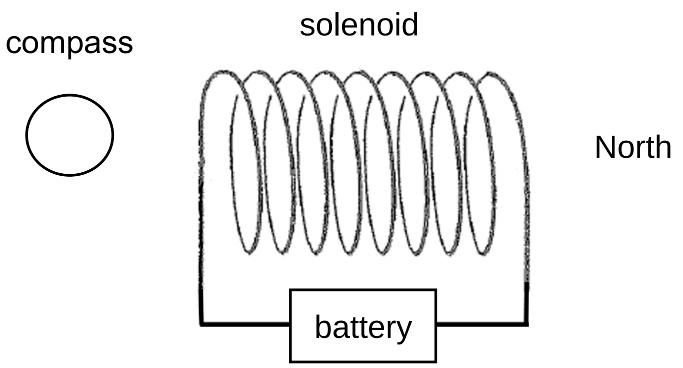

Fig. 10.1

(a) Draw an arrow at the left end of the solenoid to indicate the direction of the current flowing through the solenoid. [1]

(b) A compass is placed at the left side of the solenoid. Draw an arrow to show how will the compass needle point. [1]

(c) Fig. 10.2 shows a modified d.c. motor. The permanent magnet is replaced with the solenoid from Fig. 10.1.

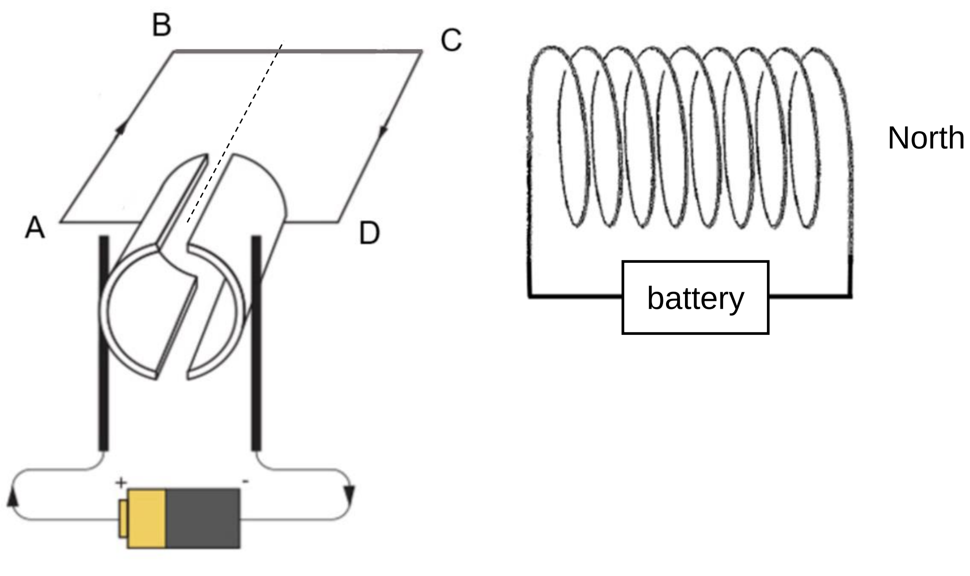

Fig. 10.2

(i) On Fig. 10.2, draw an arrow on wire AB to show the direction of the force induced on wire AB. [1]

(ii) Explain how a force is induced on wire AB.

……………………………………………………………………………………..

……………………………………………………………………………………..

……………………………………………………………………………………..

……………………………………………………………………………………..[2]

(iii) The plane of coil is initially horizontal as shown in Fig. 10.2 and the coil rotates more than 90° from this starting position. It then continues to rotate in the same direction. State and explain which feature of the d.c. motor allows the coil to continue to rotate in the same direction.

……………………………………………………………………………………..

……………………………………………………………………………………..

……………………………………………………………………………………..[2]

(d) In a typical d.c. motor, soft iron core is added to the centre of the wire coil as shown in Fig. 10.3.

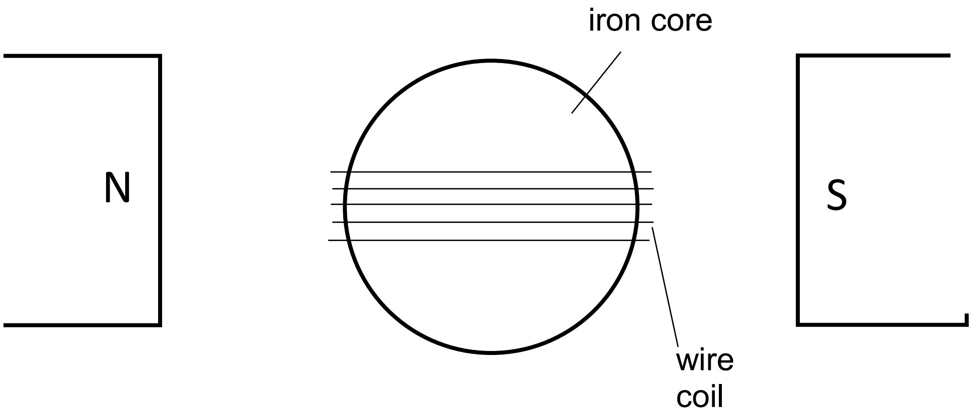

Fig. 10.3

(i) Explain how the soft iron core increases the turning effect of the d.c. motor.

……………………………………………………………………………………..

……………………………………………………………………………………..[1]

(ii) On Fig. 10.3, draw the magnetic field lines between the south pole of the magnet and the iron core when no current flows through the wire coil. [1]

(iii) Explain how the iron core is induced into a magnet.

………………………………………………………………………………………..

………………………………………………………………………………………..

…………………………………………………………………………………….[1]

11E Fig. 11.1 shows the track of a 500 kg roller coaster. An electric motor pulls the roller coaster along the track OABC. The efficiency of the electric motor is 80 % and it takes 2.0 min to pull the roller coaster from point A to point B at a constant speed.

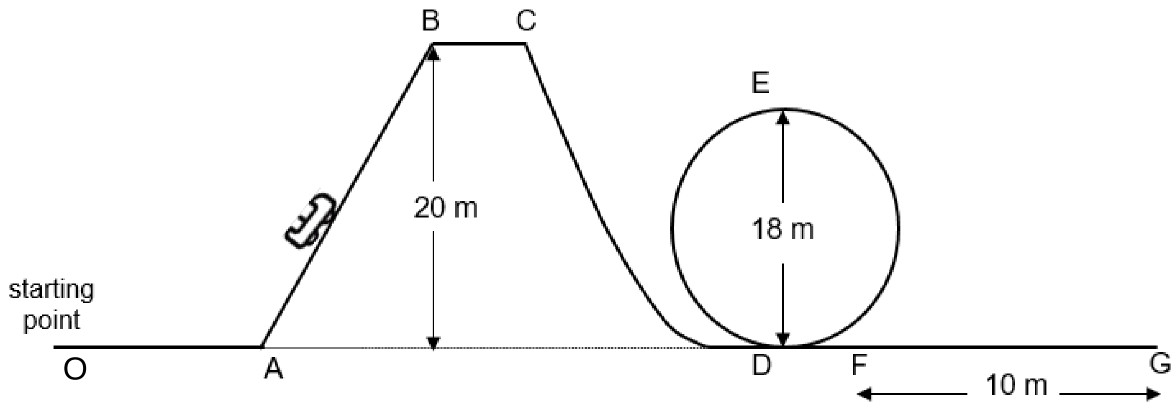

Fig. 11.1

(a) Describe how Principle of Conservation of Energy is applied as the roller coaster moves from point A to B.

………………………………………………………………………………………..

…………………………………………………………………………………….[2]

(b) Determine the power of the electric motor.

power = ... [2]

(c) The electric motor is replaced with one that gives a larger power to the roller coaster. Describe and explain the effect on the speed of the roller coaster if it still moves from A to B at a constant speed.

……………………………………………………………………………………………..

…………………………………………………………………………………………..[1]

(d) At point C, the speed of the roller coaster is 0.20 m/s and it continues to move down the track due to gravity. Assume that along the track C to F, the frictional force is negligible.

(i) Calculate the speed of the roller coaster at point E.

speed = ... [2]

(ii) In reality the speed of the roller coaster is smaller than the speed calculated in **(b)(i)**. Explain why the actual speed is lower.

………..……………………………………………………………………………..……..

………………………..…………………………………………………………….……..[1]

(e) At point F, the speed of the roller coaster is 15 m/s. The average resistive force experienced by the roller coaster along FG is 4000 N. It is observed that the 10 m track FG is not long enough for the roller coaster to come to a stop at end of track FG.

To overcome this issue, the end of track FG has to be elevated. Calculate the height of elevation of FG so that the roller coast can come to a stop at the end of the track.

height = ... [2]

11O A student uses a water tank to study the behaviour of a water wave as it travels from region A to region B of different water depths. A powerful light source placed above the water tank produces regions of bright and dark bands of light at the base of the water tank, as shown in Fig. 11.2.

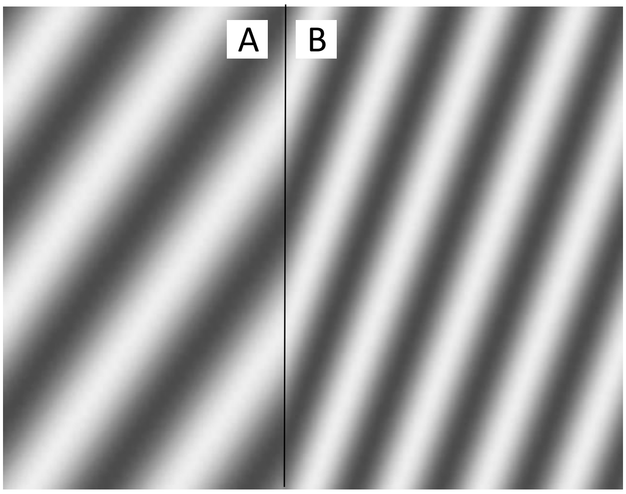

Fig. 11.2

https://web2.ph.utexas.edu/~vadim/Classes/2014f/refraction.html

(a) Explain why water waves are transverse waves.

……………………………………………………………………………………………..

……………………………………………………………………………………….…..[1]

(b) After passing through the water, light rays converge to form bright bands of light at the base of the water tank.

(i) On Fig. 11.2, mark a distance equal to the wavelength of the water wave in region A. Label the wavelength with ‘λ’. [1]

(ii) State and explain which region is deeper.

……………………..…………………………………………………………………..

……………………..…………………………………………………………………..

……………………..……………………………………………………………………..[2]

(c) At time = 0, a ping pong ball is found to be at the centre of a dark band. If the speed of the water wave is 20 cm/s and the wavelength is 10 cm, draw on Fig. 11.3, how the displacement of the ping pong ball changes with time for 2 complete oscillations. Indicate the time when the displacement = 0 mm. The amplitude of the water wave is A. [2]

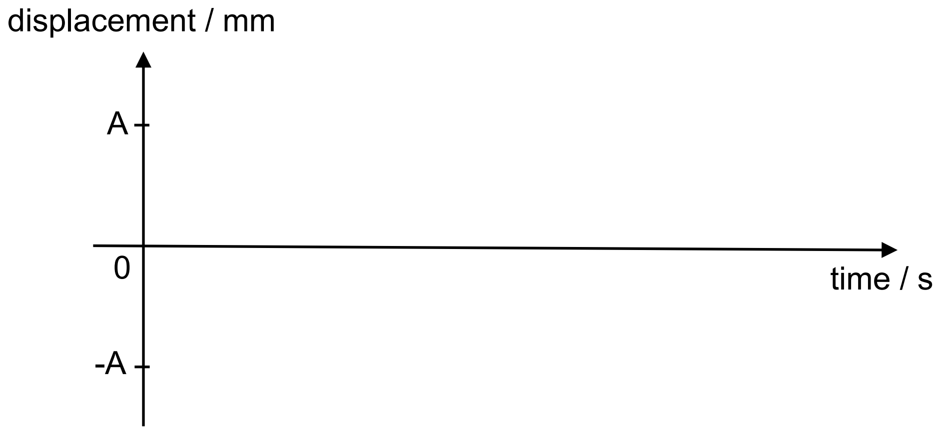

Fig. 11.3

(d) The water wave in Fig. 11.2 is produced by dropping a concrete beam into the water tank. When the beam hits the base of the tank, sound is produced. Fig. 11.4 shows the displacement-time graph of a water particle as sound is transmitted through the water.

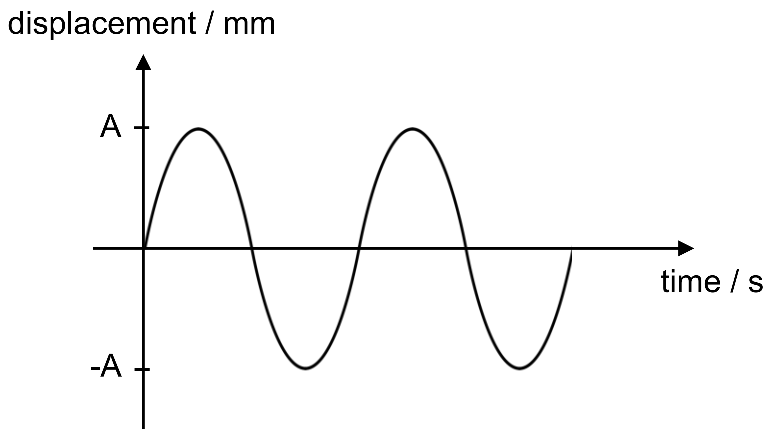

Fig. 11.4

(i) Explain how sound energy is transferred through the water without transferring matter.

……………………………………………………………………………………..

……………………………………………………………………………………..

……………………………………………………………………………………..[2]

(ii) A metal nail is also dropped into the water tank. The loudness of the sound produced by the metal nail is half that of the sound produced by the beam. The frequency of the sound produced by the metal nail is twice that of the sound produced by the beam.

Draw on Fig. 11.4, how the displacement of a water particle will change with time as the sound produced by the metal nail is transmitted through the water. [2]

END OF PAPER