PHYSICS
AT WORK
for HKDSE

Progressive Exam Resources

Sample

3 ADVANCED EXERCISE

- Two types of practices: Exercise and Revision
  - Exercise contains questions in one chapter
  - Revision contains questions in several chapters
- Advanced questions help students prepare for examinations
- **Word files** available on OUP web:

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Contents (sample)

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1 3 5 7 9 10 8 6 4 2

Class: _____ Name: _____( ) Date: _____

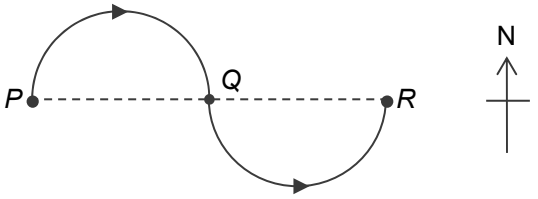
Marks: _____ / 15

Exercise 2-1

(Book 2 Chapter 1)

A Multiple-choice questions (6 marks)

(For Q1–2.) Carman skates along the path from point *P* to point *R* as shown. The path consists of two semicircles of the same radius of 20 m.



1 Which of the following statements is/are correct?

(1) She travels a total distance of 126 m.

(2) The magnitude of her total displacement is 80 m.

(3) The direction of her instantaneous velocity at *Q* points towards the east.

A (1) only B (1) and (2) only

C (1) and (3) only D (2) and (3) only

2 Carman skates at a constant speed throughout the whole process. Which of the following statements is/are correct?

(1) She is in uniform motion throughout the whole process.

(2) Her velocity at any instant is different from her average velocity over the whole process.

(3) Her speed at any instant is the same as her average speed over the whole process.

A (1) only B (2) only

C (3) only D (2) and (3) only

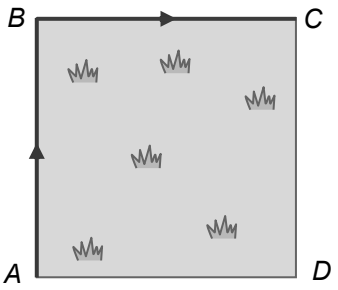
3 Kenny measures the time taken for a car to travel 100 m with a stop-watch. Then he calculates the average speed of the car from the time measured and the result is 20.0 m s^{-1}. The time measured carries an uncertainty of ±0.4 s. Which of the followings could possibly be the actual average speed of the car? Assume there is no error in the measured value of the distance travelled by the car.

A 16.9 m s^{-1} B 18.9 m s^{-1}

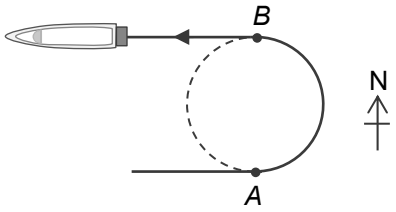
C 23.3 m s^{-1} D None of the above

B Short questions (9 marks)

4 A man walks along the sides of a square lawn. He walks with a constant speed v from A to B and a constant speed of $2v$ from B to C. Find the magnitude of his average velocity from A to C. Express your answer in terms of v. (4 marks)



5 A boat first sails towards the east and then uses 13 s to travel from A to B to reverse its direction. It sails at a constant speed of 72 km h^{-1} in the whole process. Take the direction towards the east as positive and that towards the west as negative.



(a) Find the average acceleration of the boat from A to B. (3 marks)

(b) After the turn, the boat sails with negative acceleration. Jamie claims that the boat is slowing down. Is he correct? Explain your answer. (2 marks)

- End -

Solutions

1 B

Distance travelled $= \frac{2\pi \times 20}{2} \times 2 = 126$ m

∴ (1) is correct.

Magnitude of total displacement = 20 × 4 = 80 m

∴ (2) is correct.

The instantaneous velocity at *Q* points towards the south.

∴ (3) is incorrect.

2 D

Since Carman's direction of motion changes as she skates, she is not in uniform motion.

∴ (1) is incorrect.

Since Carman skates at a constant speed *v*, her average speed is also equal to *v*.

∴ (3) is correct.

Since the magnitude total displacement < total distance travelled,

magnitude of average velocity < average speed *v*

Since magnitude of instantaneous velocity = instantaneous speed = average speed = *v*,

magnitude of instantaneous velocity > the magnitude of average velocity.

∴ (2) is correct.

3 B

Since average speed $= \frac{\text{total distance travelled}}{\text{time taken}}$, the time measured by Kenny is $\frac{100}{20} = 5$ s. The actual time taken ranges from 4.6 s to 5.4 s.

The possible average speed of the car ranges from $\frac{100}{5.4} = 18.5$ m s^{-1} to $\frac{100}{4.6} = 21.7$ m s^{-1}.

4

Let *d* be the length of each side of the path.

Magnitude of total displacement $= \sqrt{d^2 + d^2} = \sqrt{2}\,d$ — 1M

Total time taken $= \frac{d}{v} + \frac{d}{2v} = \frac{3d}{2v}$ — 1M

Magnitude of average velocity $= \frac{\sqrt{2}d}{\frac{3d}{2v}}$ — 1M

$= \frac{2\sqrt{2}v}{3}$ — 1A

5

(a) $72 \text{ km h}^{-1} = \frac{72}{3.6} \text{ m s}^{-1} = 20 \text{ m s}^{-1}$ 1M

Average acceleration $= \frac{v - u}{t}$

$= \frac{(-20) - 20}{13}$ 1M

$= -3.08 \text{ m s}^{-2}$ 1A

(b) He is incorrect. 1A

As the acceleration and the velocity have the same sign, the boat is speeding up but not slowing down. 1A

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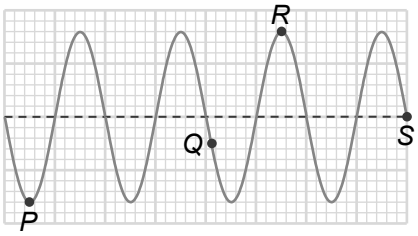
Exercise 3-4

(Book 3B Chapter 4)

A Multiple-choice questions (6 marks)

1 The figure below shows a wave travelling to the left. *P*, *Q*, *R* and *S* are four particles on the wave. The dotted line represents their equilibrium positions.



Which of the following statements is/are correct at the instant shown?

(1) Particles *P* and *Q* are moving at the same speed.

(2) The magnitude of the displacement of particle *R* measured from its equilibrium position is equal to the amplitude of the wave.

(3) Particle *S* is moving at its highest speed.

A (2) only B (3) only

C (1) and (2) only D (2) and (3) only ☐

2 Which of the following statements about a longitudinal wave is **incorrect**?

A It is caused by oscillations.

B Its waveforms consist of a series of rarefactions and compressions.

C It does not transfer particles of the medium.

D The particles on it vibrate in the direction perpendicular to its direction of propagation. ☐

3 A transverse wave propagates through a medium at 3 m s^{-1}. A particle on the wave completes 3 cycles of vibration in 1 s. Which of the following statements must be correct?

(1) The frequency of the wave is 3 Hz.

(2) The amplitude of the wave is 1 m.

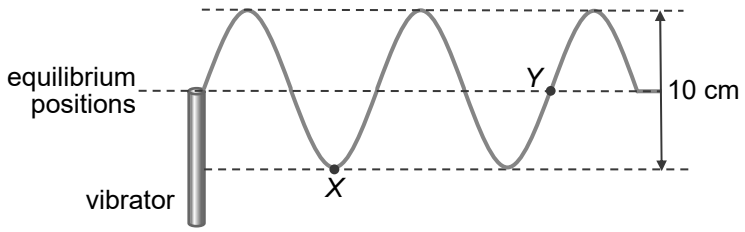
(3) The particle vibrates out of phase with another particle which is 3 m away.

A (1) only B (3) only

C (1) and (2) only D (1) and (3) only ☐

B Short question (12 marks)

4 A vibrator starts to vibrate at time $t = 0$ to produce a wave on a string. The wave propagates to the right by 3.5 cm in each complete cycle of vibration of the vibrator. The figure below shows the shape of the string at $t = 1.75$ s. X and Y are two particles on the string.



(a) Find the wave speed and the amplitude of the wave. (4 marks)

(b) How far does the wave propagate after 6 complete cycles of vibration of the vibrator? (2 marks)

(c) Sketch the s–d graph of the wave from X to Y at $t = 2.1$ s. (3 marks)

(d) The string is replaced by a thread having a lighter mass of the same length. Sketch the wave that you would expect to see in the figure. Explain briefly. (3 marks)

- End -

Solutions

1 D

Each particle keeps changing its speed as it vibrates. Different particles at different positions on a wave may vibrate at different speeds at the same instant. Only particles vibrating in phase or in antiphase have the same speed.

∴ (1) is incorrect.

Amplitude of a wave is the height of a crest from the equilibrium position.

∴ (2) is correct.

Particle at equilibrium position is moving at the highest speed.

∴ (3) is correct.

2 D

The particles on a longitudinal wave vibrate along the direction of travel of the wave.

3 A

The frequency of particle vibration is the same as the frequency of wave motion.

∴ (1) is correct.

By $v = f\lambda$,

$\lambda = \frac{v}{f} = \frac{3}{3} = 1$ m

No information on the amplitude is given in the question. It is the wavelength but not the amplitude of the wave that equals to 1 m.

∴ (2) is not necessarily correct.

A particle at 3 m away has a separation of 3λ from the particle. Therefore, the two particles are moving in phase.

∴ (3) is incorrect.

4

(a) Period $T = \frac{1.75}{2.5} = 0.7$ s 1M

Wave speed $v = \frac{\lambda}{T}$ 1M

$= \frac{0.035}{0.7}$

$= 0.05$ m s^{-1} 1A

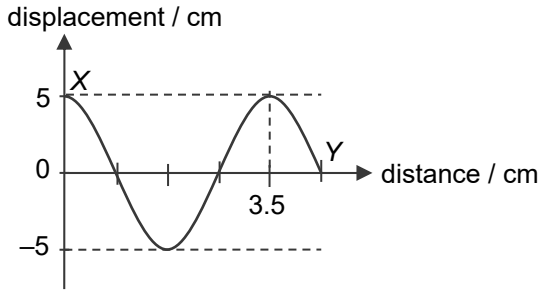
Amplitude $= \frac{0.1}{2} = 0.05$ m 1A

(b) Propagation distance of the wave $= 6\lambda$

$= 6 \times 0.035$ 1M

$= 0.21$ m 1A

(c)

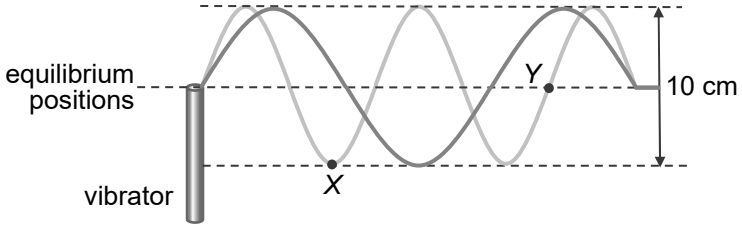


(Correct axes and labels) 1A

(Correct amplitude and wavelength) 1A

(Correct positions of *X* and *Y*) 1A

(d)



(Longer wavelength) 1A

The wave speed increases as the mass per unit length of the thread is smaller than that of the string. 1A

By $v = f\lambda$, the wavelength increases because the wave speed increases and the frequency remains constant. 1A

Class: _____ Name: _____( ) Date: _____

Marks: _____ / 28

Revision 1B

(Book 1 Chapters 1–5)

Given: c (water) = 4200 J kg^{-1} °C^{-1}, l_f (ice) = 3.34 × 10^5 J kg^{-1}, l_v (water) = 2.26 × 10^6 J kg^{-1}, universal gas constant R = 8.31 J mol^{-1} kg^{-1}

A Multiple-choice questions (6 marks)

1 A few lumps of dry ice turn into gas in a closed box which does not exchange heat with the surroundings. Which of the following statements is/are correct?

(1) The dry ice releases latent heat as it changes from solid to gas.

(2) The dry ice molecules in gas state have more freedom of movement than in solid state.

(3) The net change in total amount of energy of the box is zero.

A (1) only B (1) and (2) only

C (2) and (3) only D (1), (2) and (3) ☐

2 On a cold winter day, Alice wears a down jacket to keep herself warm. This jacket

(1) reduces the amount of heat loss by conduction.

(2) is warmer than her body.

(3) does not emit radiation to the surroundings.

A (1) only B (1) and (2) only

C (1) and (3) only D (2) and (3) only ☐

3 Bella puts two identical beakers of water in two rooms at different temperatures. She finds that water evaporates at a higher rate in the warmer room. Which of the following statements can explain the result?

A The water only absorbs energy from the surroundings but does not lose any energy in the warmer room.

B Vapour molecules do not return to the liquid surface in the warmer room.

C More water molecules can escape as they have higher average kinetic energy in the warmer room.

D Water molecules can escape into the air directly from the centre of the liquid after absorbing enough energy in the warmer room ☐

B Short questions (22 marks)

Ext **4** Nitrogen is usually used to lengthen the shelf life of food. Calvin buys a bag of potato chips. At temperature of 20 °C and pressure of 100 kPa, the volume of the bag is 640 cm^3 and half the volume is occupied by nitrogen. Assume that the nitrogen inside the bag is an ideal gas.
Given: molar mass of nitrogen = 28.0 g mol^{-1}

(a) Find the root-mean-square speed of the nitrogen molecules inside the bag. (2 marks)

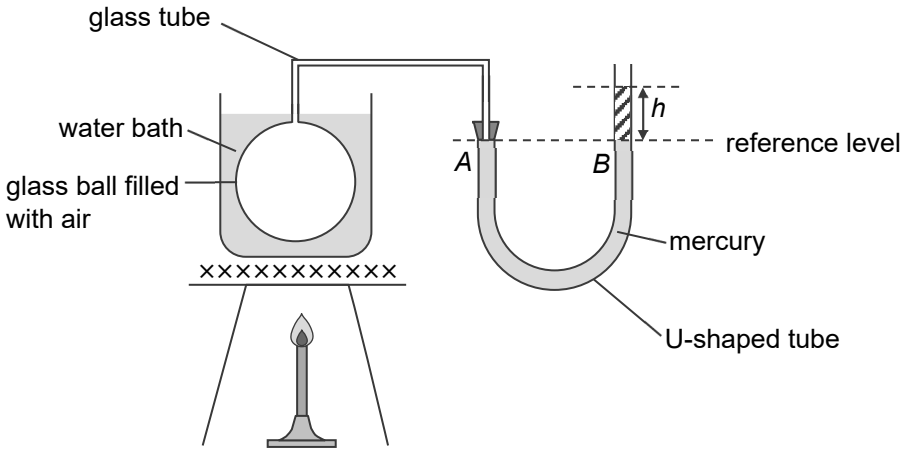
(b) Calvin claims that all the nitrogen molecules in the bag move at the root-mean-square speed. Comment on his statement. (2 marks)

(c) Calvin climbs a mountain with the bag of chips. When he reaches the top of the mountain, he finds that the temperature drops and the bag inflates.

(i) Consider the change of the bag. Is the atmospheric pressure on the top of the mountain higher or lower than that at the bottom? Explain briefly. (2 marks)

(ii) Suppose the temperature decreased by 20% and the volume of the nitrogen inside the bag increases by 20% on the top of the mountain. Find the atmospheric pressure there. (2 marks)

Ext **5** In the set-up below, a glass ball filled with air is connected to a U-shaped tube via a glass tube of negligible volume. The glass ball is immersed in a water bath. The U-shaped tube contains some mercury.



Before the Bunsen burner is turned on, the mercury levels at sides *A* and *B* are at the reference level and the water bath is at room temperature. The gas pressure inside the glass ball is p_0. When the Bunsen burner is turned on to heat the water bath, extra mercury is added into side *B* of the U-shaped tube to maintain the mercury level at side *A*.

The gas pressure p inside the glass ball can be expressed as

$$p = p_0 + kh$$

where k is a constant, and h is the height of the mercury level measured from the reference level at side *B*.

(a) (i) What happens to the gas pressure inside the glass ball when the water bath is being heated? Explain your answer by using the kinetic theory of gases. (3 marks)

(ii) What does the term kh represent? (1 mark)

(b) The temperature of the water bath increases from 20 °C to 80 °C. Find the value of h when the water bath is at 80 °C. Given: p_0 = 100 kPa, k = 133 kPa m^{-1}. (3 marks)

6 Sometimes milk foam is added into coffee to change its texture and favour. Matthew uses the steamer on a coffee machine to make milk foam by pumping steam at 100 °C into 600 g of milk until the temperature of the mixture reaches 65 °C.

Given: specific heat capacity of milk = 3930 J kg^{-1} °C^{-1}

(a) The milk is initially at 4 °C. Estimate the mass of steam pumped into the milk. Assume that all the steam condenses and stays in the mixture. (2 marks)

(b) The steamer produces steam at 100 °C using water at 20 °C at a rate of 0.18 g s^{-1}. Estimate the power of the steamer. (2 marks)

(c) Matthew puts ice at 0 °C into a glass of hot coffee at 80 °C to make iced coffee. Some ice remains in the coffee when the coffee reaches 0 °C. The coffee is then left on the table for a long time. The room temperature is 23 °C. Sketch a graph to show how the temperature T of the coffee changes with time t in the whole process. (3 marks)

- End -

Solutions

1 C

Dry ice needs energy to change to liquid or gas. It absorbs latent heat when changing its state.

∴ (1) is incorrect.

By the law of conservation of energy, the total amount of energy in a closed system does not change.

∴ (3) is correct.

2 A

The feather in a down jacket can trap air, which is a poor conductor of heat. Energy loss by conduction can be reduced.

∴ (1) is correct.

The jacket does not produce heat. Its temperature will not be higher than the body temperature.

∴ (2) is incorrect.

Every object emits radiation.

∴ (3) is incorrect.

3 C

All objects radiate energy in all directions.

∴ A is incorrect.

Vapour molecules return to the water when they lose energy. What Bella observes is the net rate of evaporation. It is the difference between the rate of escape and the rate of return.

∴ B is incorrect.

Evaporation only occurs at the surface of a liquid.

∴ D is incorrect.

In the warmer room, the water has a higher temperature, so the water molecules have higher average kinetic energy. More molecules have enough energy to escape from the water surface.

∴ C is correct.

4

(a) $\overline{c} = \sqrt{\dfrac{3RT}{mN_A}}$ 1M

$= \sqrt{\dfrac{3\times 8.31\times(20+273)}{0.0280}} = 511 \text{ m s}^{-1}$ 1A

(b) He is not correct. 1A

The r.m.s. speed is the typical speed of molecules at a certain temperature.

The nitrogen molecules have a wide range of speeds. 1A

(c) (i) By $\dfrac{pV}{T}$ = constant, 1A

When T decreases and V increases, p decreases. Therefore, the atmospheric pressure on the top of the mountain is lower. 1A

(ii) By $\frac{p_1V_1}{T_1} = \frac{p_2V_2}{T_2}$,

$\frac{(100)V}{T} = \frac{p_2(1+20\%)V}{(1-20\%)T}$ 1M

$p_2 = 66.7$ kPa

The atmospheric pressure is 66.7 kPa. 1A

5

(a) (i) The gas pressure inside the glass ball increases. 1A

According to the kinetic theory, the gas molecules move faster as temperature increases. 1A

As the volume of the glass ball is fixed, the molecules hit their walls more frequently and more violently. 1A

As a result, the pressure increases.

(ii) The pressure exerted on the gas by the extra mercury added. 1A

(b) By $\frac{p_1}{T_1} = \frac{p_2}{T_2}$,

$p_2 = \frac{p_1T_2}{T_1} = \frac{(100)\,(80+273)}{20+273}$ 1M

$= 120.48$ kPa 1A

By $p = p_0 + kh$,

$120.48 = 100 + (133)h$

$h = 0.154$ m 1A

6

(a) Energy lost by the steam = energy gained by the milk

$m_s l_v + m_s c_w \Delta T_w = m_m c_m \Delta T_m$

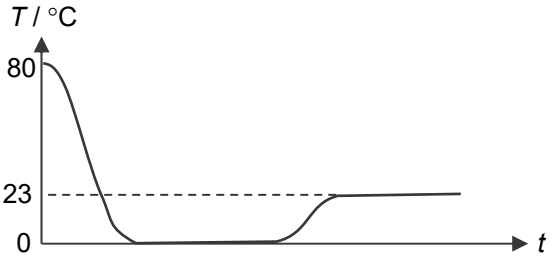
$m_s \times [2.26 \times 10^6 + 4200 \times (100 - 65)] = (0.6) \times 3930 \times (65 - 4)$ 1M

$m_s = 0.0598$ kg 1A

(b) $P = (0.18 \times 10^{-3}) \times [4200 \times (100 - 20) + 2.26 \times 10^6]$ 1M

$= 467$ W 1A

(c)



(Decrease from 80 °C to 0 °C) 1A

(Remain at 0 °C for a period of time) 1A

(Finally reach 23 °C) 1A

Class: _____ Name: _____( ) Date: _____

Marks: _____ / 33

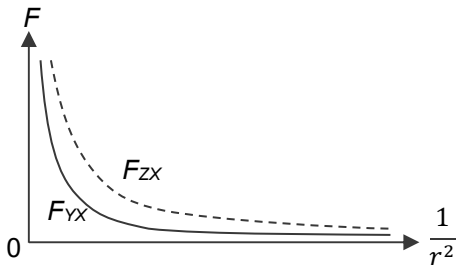
Revision 4A

(Book 4 Chapters 1–4)

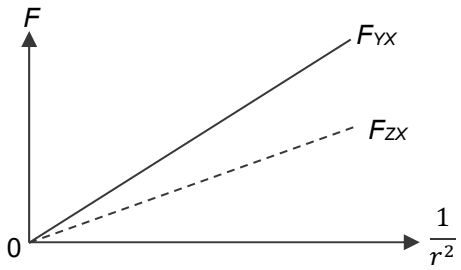
A Multiple-choice questions (8 marks)

1 X and Y are two point charges separated by a distance r. X carries a charge of $+q$ and Y carries a charge of $-3q$. Then Y is removed and replaced by another point charge Z, which carries a charge of $-5q$. The force acting on Y by X is F_{YX} and the force acting on Z by X is F_{ZX}. Which of the following graph best shows how the size of F_{YX} and F_{ZX} change with $\frac{1}{r^2}$?

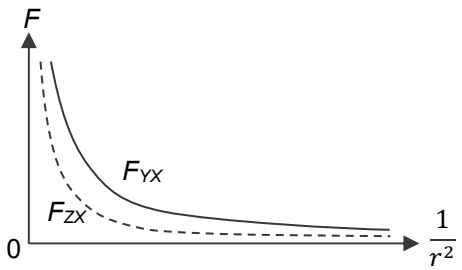
A



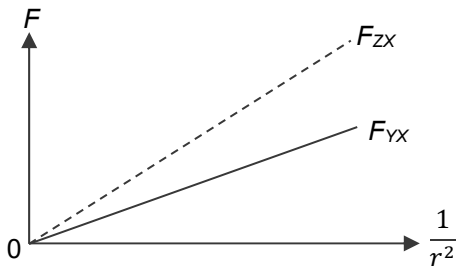
B



C

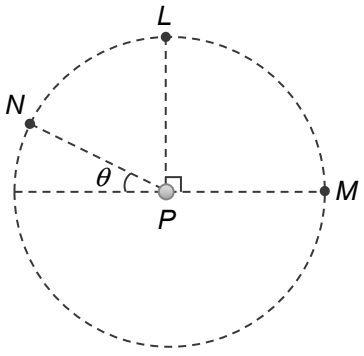


D



☐

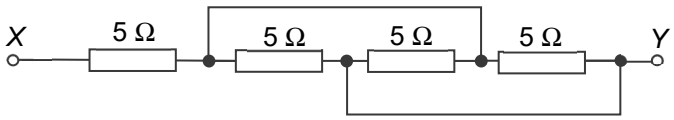
2 Three point charges L, M and N are at the circumference of a circle. L and M carry charges of $-Q$ and $-2Q$ respectively. Test charge P with charge $+q$ is at the centre of the circle. If the net electrostatic force acting on P points towards L, which of the following is a possible combination of angle θ and the charge carried by N?



	Angle θ	**Charge carried by N**
A	30°	$+2Q$
B	30°	$-2Q$
C	60°	$+4Q$
D	60°	$-4Q$

☐

3 The network below consists of four 5-Ω resistors.



Find the equivalent resistance across *X* and *Y*.

A 1.25 Ω B 7.5 Ω

C 6.67 Ω D 20 Ω ☐

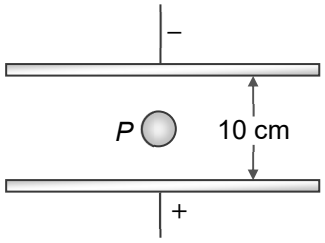
4 A cylindrical conductor *X* has a radius of $2r$ and a resistivity of 3ρ. Its resistance is *R*. Another cylindrical conductor *Y* has the same length as conductor *X* but has a radius of *r* and a resistivity of ρ. What is the resistance of conductor *Y*?

A $\frac{1}{12}R$ B $\frac{1}{6}R$

C $\frac{2}{3}R$ D $\frac{4}{3}R$ ☐

B Short questions (25 marks)

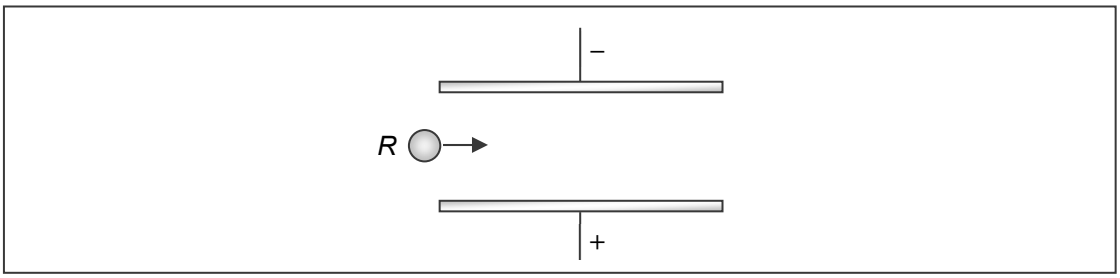
5 A charged particle *P* remains stationary at the middle between two horizontal metal plates as shown. The plates are separated by 10 cm and are oppositely charged.



(a) Is *P* positively charged or negatively charged? Explain your answer. (2 marks)

Ext **(b)** Given that the mass of *P* is 0.8 g and the quantity of charge in *P* is 0.225 μC, find the voltage across the two plates. (2 marks)

Ext **(c)** P is now removed. Another particle R has the same mass as P but carries opposite charge. R is projected horizontally to the right to enter the electric field.



(i) Sketch the path of R in the figure. (1 mark)

(ii) Suppose R does not hit any object when moving between the plates. Does the net force acting on R change? (1 mark)

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6 Catherine wants to measure the internal resistance r of a battery with e.m.f. ε. She sets up the circuit shown in Figure 6.1.

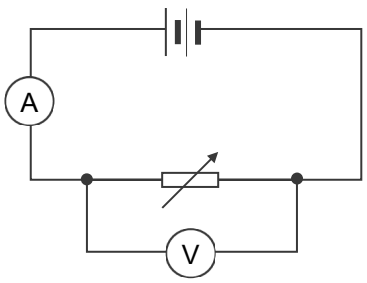


Fig 6.1

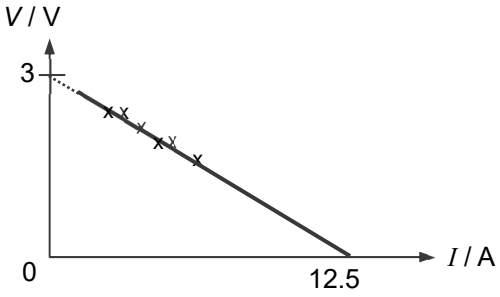


Fig 6.2

She varies the resistance of the rheostat and records the corresponding readings I and V of the ammeter and voltmeter. She then plots a graph of V against I as shown in Figure 6.2. Suppose the ammeter and voltmeter are ideal.

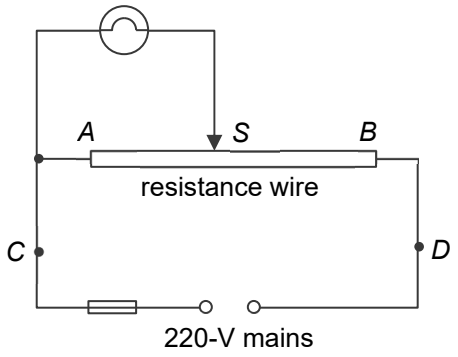
(a) If the rheostat is removed and the voltmeter is connected in series with the battery, what is the physical meaning of the voltmeter reading? (1 mark)

(b) Express V in terms of ε, r and I. (1 mark)

(c) With reference to your answer in (b) and Figure 6.2, estimate the e.m.f. ε and the internal resistance r of the battery. (3 marks)

(d) If the ammeter is not ideal, will the estimated values in (c) be higher or lower than the actual values? (2 marks)

7 Tom designs a circuit to control the brightness of a filament bulb as shown. Uniform resistance wire AB is 30 cm long and has a resistance of 1800 Ω. It is connected to the 220-V mains and the bulb is connected to the resistance wire via a slider S. The brightness of the bulb can be changed by moving S along the resistance wire. The resistance of the bulb is 1000 Ω.



Ext **(a)** What is the peak value of the mains voltage? (1 mark)

Ext **(b)** How does the electric potential at points C and D change with time? (2 marks)

Ext **(c)** Find the average power consumed by the resistance wire and the bulb when *S* is 20 cm from *A*. (5 marks)

(d) Ben suggests replacing the resistance wire with another one of a smaller resistance. Do you agree with him? Explain briefly. (2 marks)

(e) If the whole resistance wire is shorted, will the bulb light up? Will the fuse blow? (2 marks)

- End -

Solutions

1 D

As the electrostatic force F between two charges is given by $\frac{Q_1Q_2}{4\pi\varepsilon_0}\frac{1}{r^2}$, F is directly proportional to $\frac{1}{r^2}$. The graph of F against $\frac{1}{r^2}$ should be a straight line passing through the origin with positive slope. When Y is replaced by Z, the slope of the graph, given by $\frac{Q_1Q_2}{4\pi\varepsilon_0}$, will become larger.

Therefore, the graph of F_{ZX} has a larger slope than that of F_{YX}.

2 D

Since the net electrostatic force points towards L, the forces exerted on P by M and N balance with each other along the horizontal direction. This means the force by N is also attractive and N carries a negative charge.

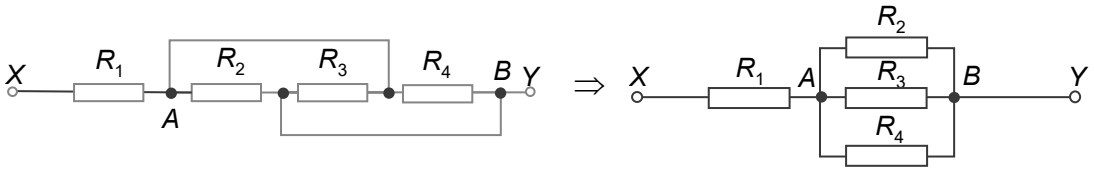
Along the horizontal direction,

$$F_N\cos\theta = F_M \quad \Rightarrow \quad \frac{1}{4\pi\varepsilon_0}\frac{Q_N q}{r^2}\cos\theta = \frac{1}{4\pi\varepsilon_0}\frac{Q_M q}{r^2} \quad \Rightarrow \quad Q_N\cos\theta = 2Q \quad \Rightarrow \quad Q_N > 2Q$$

If N carries a charge of $-4Q$, $4Q\cos\theta = 2Q \quad \Rightarrow \quad \theta = 60°$

3 C

Rearrange the network as follow by considering the resistors connected to junctions A and B.



Equivalent resistance $= 5 + \left(\frac{1}{5}+\frac{1}{5}+\frac{1}{5}\right)^{-1} = 6.67\ \Omega$

4 D

Resistance of the copper conductor $R = 3\rho\frac{l}{A} = 3\rho\frac{l}{\pi(2r)^2} = \frac{3\rho l}{4\pi r^2}$

Resistance of the metal conductor $= \rho\frac{l}{\pi r^2} = \frac{4}{3}R$

5

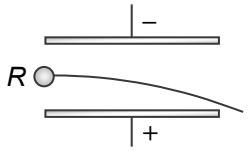
(a) P is positively charged.	1A
so that the electrostatic force acting on it by the plates points upwards to balance the weight of P.	1A

(b) Since $mg = Eq = \frac{qV}{d}$,

$$V = \frac{mgd}{q} = \frac{0.8\times10^{-3}\times9.81\times0.10}{0.225\times10^{-6}}$$ 1M

$$= 3490 \text{ V}$$ 1A

(c) (i)



1A

(ii) No 1A

6

(a) E.m.f. of the battery 1A

(b) $V = \varepsilon - Ir$ 1A

(c) Slope of V–I graph $= -r$

$$\frac{0-3}{12.5-0} = -r$$ 1M

$$r = 0.24\ \Omega$$ 1A

When $I = 0$, $V = \varepsilon$ and so ε is 3 V. 1A

(d) The estimated value of the internal resistance is higher than the actual value, 1A

while that of the e.m.f. is the same as the actual value. 1A

7

(a) Peak value $= \sqrt{2} \times 220 = 311$ V 1A

(b) The electric potential at C varies from 311 V to –311 V. 1A

The electric potential at D remains 0 V. 1A

(c) Equivalent resistance of the circuit R_{eq}

= resistance of SB + equivalent resistance of AS and bulb

$$= \frac{10}{30}\times1800 + \left(\left(\frac{20}{30}\times1800\right)^{-1} + (1000)^{-1}\right)^{-1}$$

$$= 600 + 545.45$$

$$= 1145.45\ \Omega$$ 1M

R.m.s. voltage across bulb

$$= \frac{545.45}{600+545.45}\times220$$

$$= 104.76 \text{ V}$$ 1M

Average power consumed by bulb

$= \frac{V_{rms}^2}{R}$

$= \frac{104.76^2}{1000}$

$= 11.0$ W — 1A

Average power consumed by the circuit

$= \frac{V_{rms}^2}{R}$

$= \frac{220^2}{1145.45}$

$= 42.3$ W — 1M

Average power consumed by resistance wire

$= 42.3 - 11.0$

$= 31.3$ W — 1A

(d) No, — 1A

the energy wasted by the wire will increase. — 1A

(e) The fuse will blow — 1A

and the bulb will not light up. — 1A