2017-DSE
PHY
PAPER 1B

B

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HONG KONG EXAMINATIONS AND ASSESSMENT AUTHORITY
HONG KONG DIPLOMA OF SECONDARY EDUCATION EXAMINATION 2017

Candidate Number

PHYSICS PAPER 1

SECTION B : Question-Answer Book B

This paper must be answered in English

INSTRUCTIONS FOR SECTION B

(1) After the announcement of the start of the examination, you should first write your Candidate Number in the space provided on Page 1 and stick barcode labels in the spaces provided on Pages 1, 3, 5, 7 and 9.

(2) Refer to the general instructions on the cover of the Question Paper for Section A.

(3) Answer **ALL** questions.

(4) Write your answers in the spaces provided in this Question-Answer Book. Do not write in the margins. Answers written in the margins will not be marked.

(5) Graph paper and supplementary answer sheets will be provided on request. Write your Candidate Number, mark the question number box and stick a barcode label on each sheet, and fasten them with string **INSIDE** this Question-Answer Book.

(6) No extra time will be given to candidates for sticking on the barcode labels or filling in the question number boxes after the 'Time is up' announcement.

Question No.	Marks
1	7
2	5
3	4
4	10
5	8
6	10
7	11
8	12
9	10
10	7

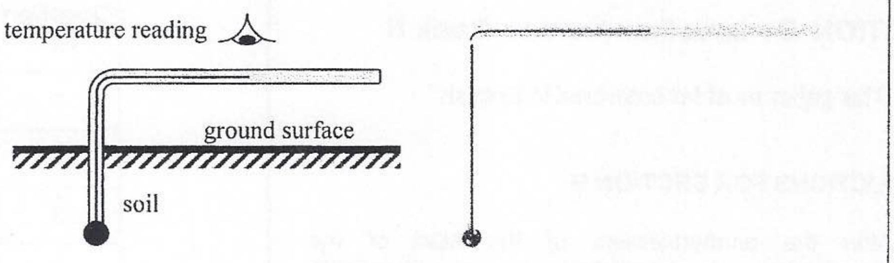
A150E01B

Section B: Answer **ALL** questions. Parts marked with * involve knowledge of the extension component. Write your answers in the spaces provided.

1. Read the following passage about **soil thermometer** and answer the questions that follow.

The temperature of soil changes with depth, and this information is important to farmers and scientists. To measure soil temperatures at depths close to the ground surface, the bulb of a thermometer is buried in the soil. The stem of the thermometer is bent 90° for easy reading. Figure 1.1a is a schematic diagram and Figure 1.1b shows a photo of a soil thermometer.

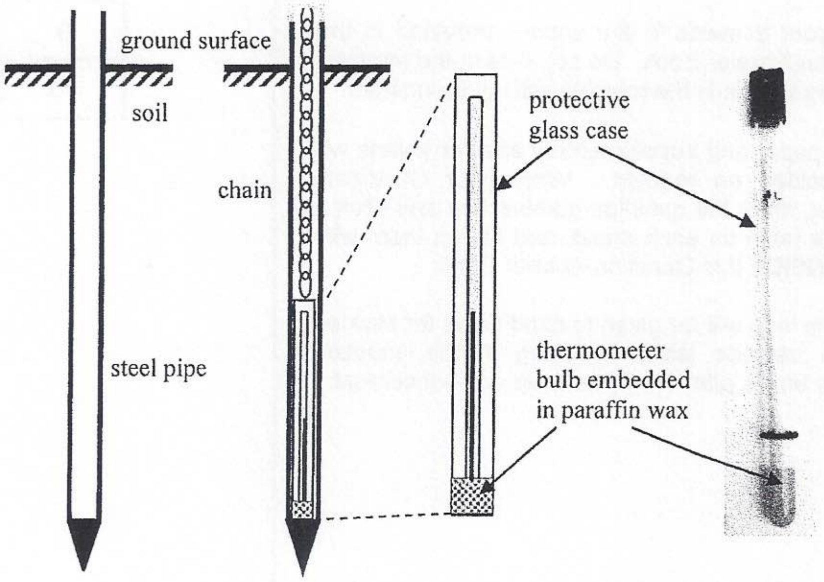
Figure 1.1



(a) (b)

For depths greater than 30 cm, a steel pipe is driven into the soil (Figure 1.2a); and a liquid-in-glass thermometer with a protective glass case is lowered into the steel pipe (Figure 1.2b). The bulb of the thermometer is embedded in paraffin wax (Figure 1.2c). To read the temperature, the thermometer is lifted out of the steel pipe by pulling the chain.

Figure 1.2



(a) (b) (c)

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(a) As shown in Figure 1.1b, the bulb of the soil thermometer is very large compared to those of common thermometers. Suggest a reason for this design. (1 mark)

(b) On a certain morning, the air temperature is 15°C. An observer takes a measurement of the soil temperature at 1 m deep. The thermometer reading is 20°C. It is given that the mass of the paraffin wax enclosing the thermometer bulb is 0.015 kg, and the specific heat capacity of paraffin wax is 2.9×10^3 J kg^{-1} °C^{-1}.

(i) Calculate the energy loss of the paraffin wax as it cools down to the air temperature. (2 marks)

(ii) It is known that the paraffin wax enclosing the bulb of the thermometer gains or loses energy at a constant rate of 0.5 J s^{-1}, estimate the time taken for the paraffin wax to reach the air temperature after the thermometer is lifted out of the soil. (2 marks)

(iii) If there is no paraffin wax enclosing the bulb of the thermometer, explain how the thermometer reading as recorded by the observer is affected. (2 marks)

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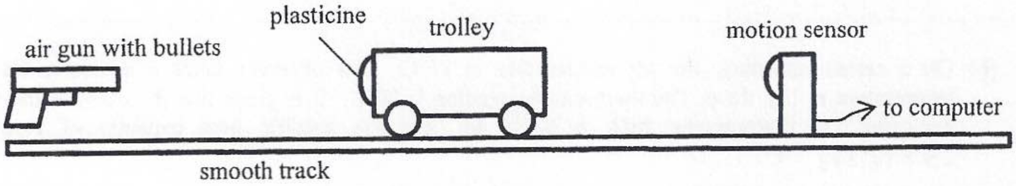
2. The following experimental items are provided to set up an experiment to estimate the speed of a bullet fired from an air gun.

a smooth track
a trolley
a motion sensor used to measure the speed of the trolley
some plasticine
an air gun and bullets
an electronic balance

The set-up is shown in Figure 2.1.

Figure 2.1



Describe the procedures of the experiment. State the physical quantities to be measured and an equation for finding the speed of the bullet. Write down **ONE** precaution for getting a more accurate result. (5 marks)

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*3. The average kinetic energy of one monatomic gas molecule at temperature T is given by

$$E_K = \frac{3}{2}\left(\frac{R}{N_A}\right)T,$$

where R is the universal gas constant and N_A is the Avogadro constant. A monatomic gas is heated from 300 K to 350 K under fixed volume.

(a) Estimate the ratio of the root-mean-square speed ($c_{r.m.s.}$) of the gas molecules at the two temperatures ($\frac{c_{r.m.s.} \text{ at } 350\text{ K}}{c_{r.m.s.} \text{ at } 300\text{ K}}$). (2 marks)

(b) Thus, using kinetic theory, explain why the gas pressure would increase. (2 marks)

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4. (a) A steel ball bearing is released from rest at time $t = 0$. A stroboscopic photo is taken at 0.05 s time intervals. The results are shown in Figure 4.1. Neglect air resistance.

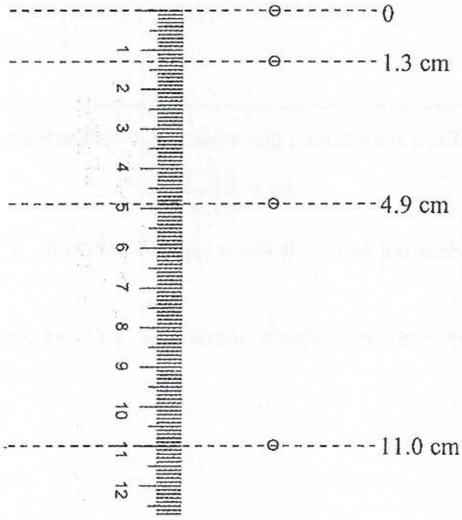

Figure 4.1

(i) Estimate the acceleration due to gravity using the data in Figure 4.1. (2 marks)

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*(ii) The bearing is now projected horizontally instead of released from rest. The bearing is projected at time $t = 0$, and a stroboscopic photo is taken at 0.05 s time intervals. The first and the last image of the stroboscopic photo are shown using circles (**O**) in Figure 4.2. For reference, the stroboscopic photo of the bearing released from rest is also shown in the figure using crosses (x).

Figure 4.2

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Answers written in the margins will not be marked.

(1) In Figure 4.2, mark the positions of the projected bearing in the stroboscopic photo using circles (**O**). (2 marks)

(2) Given that the bearing is projected horizontally with an initial speed of 1 m s^{-1}, use the results of (a)(i) to calculate the speed of the projected bearing when the last image was taken. (3 marks)

(b) If a small ball is released from rest from the top of a cliff, the speed of the ball becomes constant after a period of time. By considering the forces acting on the ball and using Newton's laws of motion, explain why the speed of the ball becomes constant. (3 marks)

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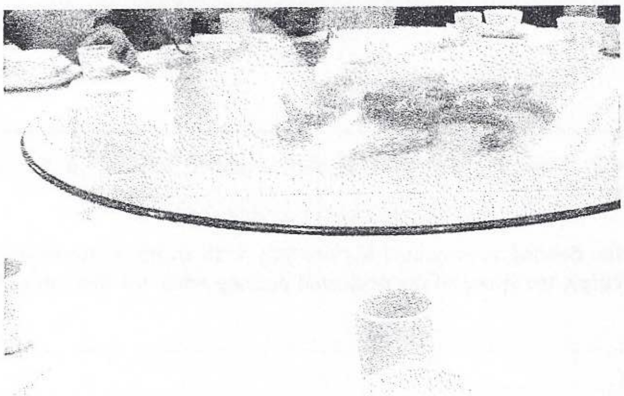
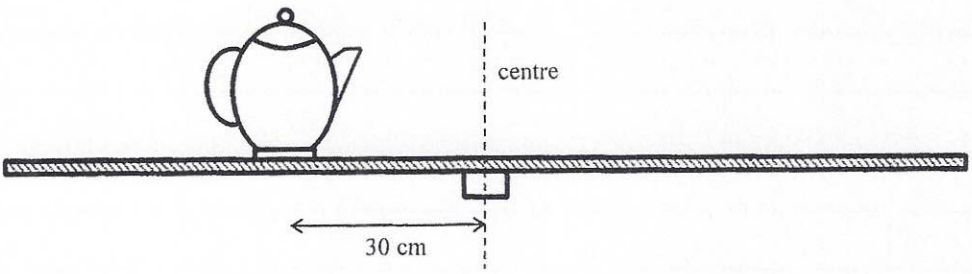
*5. The photo shows a turntable commonly used in restaurants.



A teapot of mass 1 kg is put 30 cm from the centre of a horizontal turntable, Figure 5.1 shows the side view. When the turntable is rotating, the teapot remains at the same position on the turntable.

Figure 5.1



(a) On Figure 5.1, draw and label all the forces acting on the teapot when the turntable is rotating. (2 marks)

(b) Taking the teapot as a point mass, estimate the net force acting on the teapot when the turntable is rotating at a rate of 0.5 revolutions per second. (3 marks)

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(c) The turntable is suddenly stopped and the teapot slips. The turntable is rotating at a rate of 0.5 revolutions per second just before it stops, and the frictional force acting on the teapot is 10 N when it is slipping. Determine the distance travelled by the teapot after the turntable stops. (3 marks)

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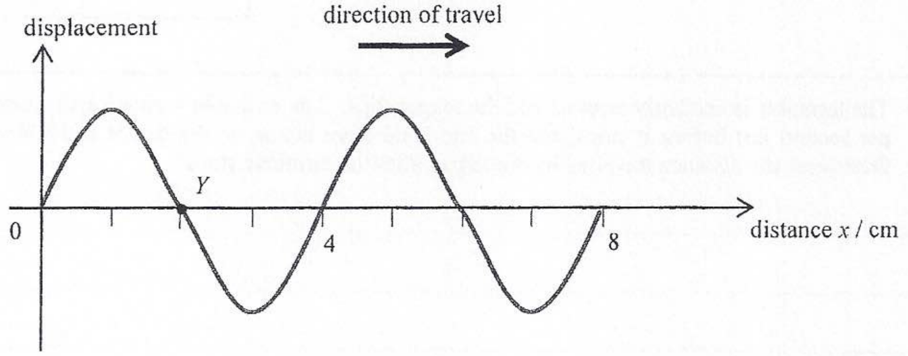
6. (a) A dipper vibrating with a frequency of 5 Hz is put in a water tank. Figure 6.1 shows the displacement-distance graph of the water wave at time $t = 0$. Y is a particle in the water tank.

Figure 6.1



(i) Determine the wave speed of the water wave. (2 marks)

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(ii) State the direction of motion of particle Y at $t = 0$. (1 mark)

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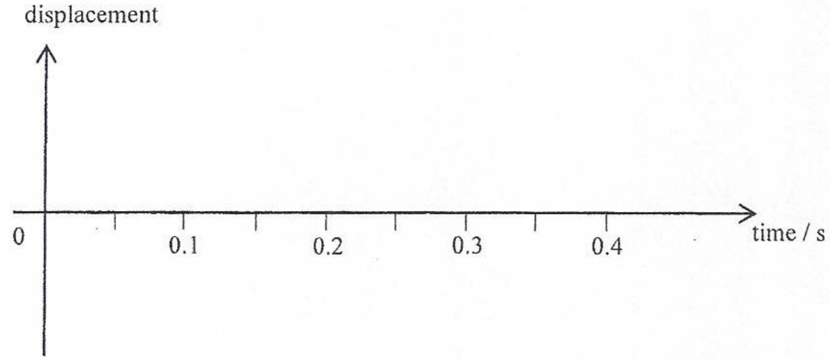
(iii) Sketch the displacement-time graph of particle Y between $t = 0$ and $t = 0.4$ s in Figure 6.2. (2 marks)

Figure 6.2



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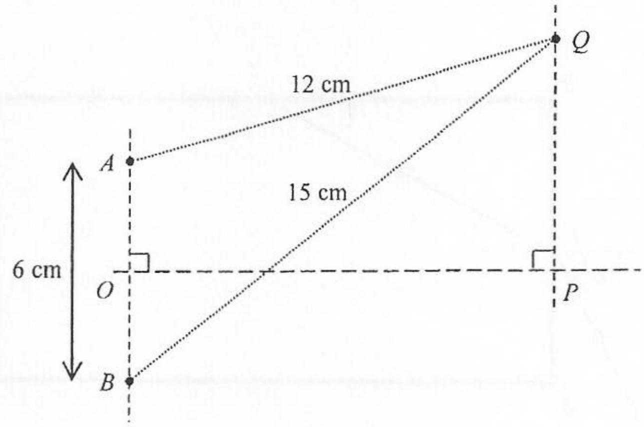
(b) In Figure 6.3, A and B are two dippers vibrating in phase in a water tank. The distance between A and B is 6 cm. OP is the perpendicular bisector of AB. Q is a second minimum from P, where AQ = 12 cm and BQ = 15 cm.

Figure 6.3



(i) Explain why a minimum occurs at Q. (2 marks)

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(ii) Determine the wavelength of the water wave. (2 marks)

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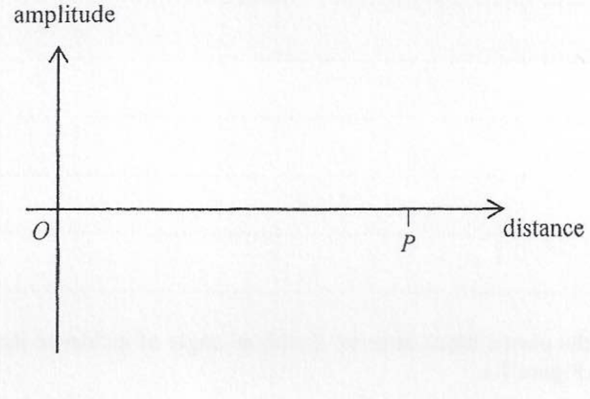
(iii) Sketch in Figure 6.4 how the **AMPLITUDE** of the water wave varies along the line OP. (1 mark)

Figure 6.4



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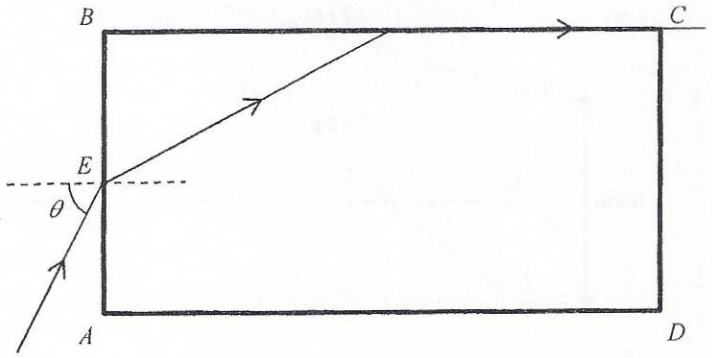
7. (a) A light ray enters a rectangular plastic block $ABCD$ from air at point E, and the angle of incidence is θ. The light ray emerges along face BC as shown in Figure 7.1. The refractive index of the plastic is 1.36.

Figure 7.1



(i) Find the critical angle of the plastic. (2 marks)

(ii) Find the value of θ. (3 marks)

(iii) If the light ray enters the plastic block at point E with an angle of incidence larger than θ, sketch the path of the light ray in Figure 7.1. (2 marks)

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(b) A student designs a periscope using two plastic prisms, the refractive index of the plastic is 1.36. As shown in Figure 7.2, an object is placed in front of the periscope.

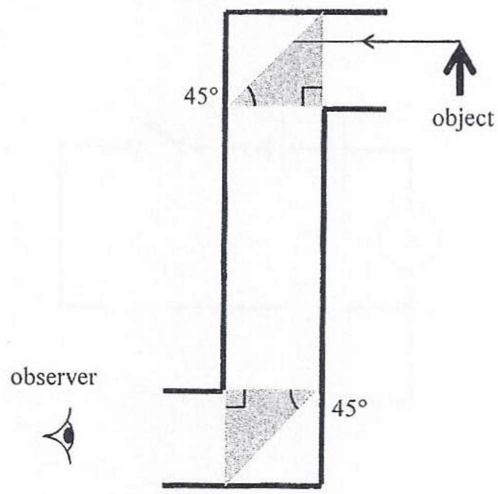

Figure 7.2

(i) Complete the path of the light ray from the object in Figure 7.2, and explain why the periscope fails to work. (3 marks)

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(ii) What can be used to replace the two plastic prisms so that the periscope can work properly ? (1 mark)

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8. A student uses the following apparatus to measure the resistance of a tungsten filament light bulb.

a battery, a switch, a variable resistor, an ammeter, a voltmeter, a light bulb

(a) Figure 8.1 shows an incomplete circuit for the experiment. The '+' symbol represents the positive terminal of the ammeter.
Use suitable circuit symbols to complete the circuit, and mark the positive terminal of the voltmeter with '+'. (3 marks)

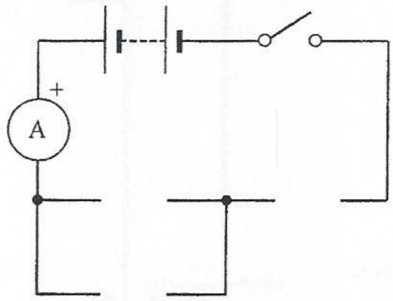

Figure 8.1

The table below and Figure 8.2 show the results obtained.

Voltage across the light bulb V / V	0	0.1	0.2	0.3	0.4	0.5	1.0	2.0	3.0
Current I / mA	0	76	112	126	133	139	170	226	273

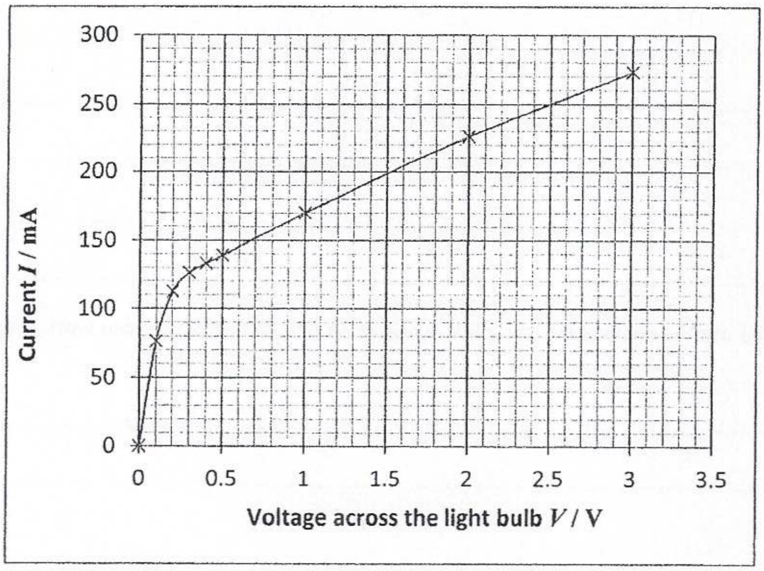

Figure 8.2

Answers written in the margins will not be marked.

(b) Briefly explain the variation of the resistance of the light bulb with the voltage across the light bulb. (2 marks)

(c) The student claims that since the resistance of the light bulb is not a constant, the equation $R = V/I$ cannot be used to calculate the resistance of the light bulb. Briefly explain why his claim is wrong. (1 mark)

(d) Determine the resistance of the light bulb at $V = 0.1$ V and 2.5 V. (3 marks)

(e) It is given that the cross-sectional area of the tungsten filament in the light bulb is 1.66×10^{-9} m^2, and the resistivity of tungsten at room temperature is about 5.6×10^{-8} Ω m. Estimate the length of the tungsten filament in the light bulb using the appropriate resistance found in (d). (3 marks)

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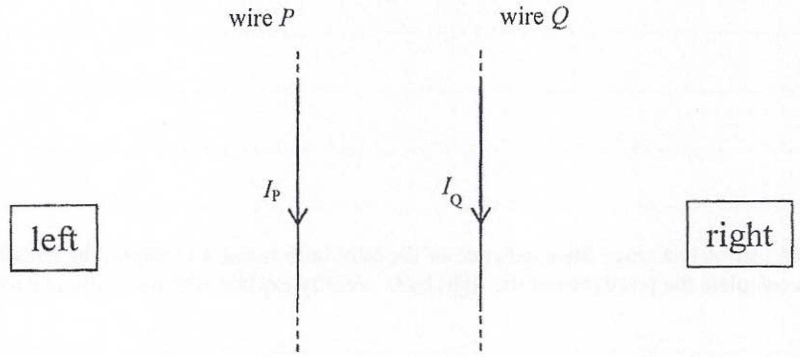
9. (a) Two long straight current carrying wires, P and Q, are parallel to each other and lie on the plane of the paper as shown in Figure 9.1. The currents in the wires, I_P and I_Q, flow in the same direction.

Figure 9.1



(i) State the direction (to the left / to the right / into the paper / out of the paper) of the magnetic field at Q due to P. (1 mark)

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(ii) In Figure 9.1, draw the direction of the magnetic force acting on Q due to P. (1 mark)

(iii) Show that the magnitude of the magnetic force per unit length F_l acting on Q due to P is

$$F_l = \frac{\mu_o I_P I_Q}{2\pi r},$$

where μ_o is the permeability of free space and r is the separation between the two wires. (3 marks)

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(iv) For the magnetic force acting on Q due to P and the magnetic force acting on P due to Q, if $I_P \neq I_Q$, briefly explain whether the two forces are equal in magnitude. (2 marks)

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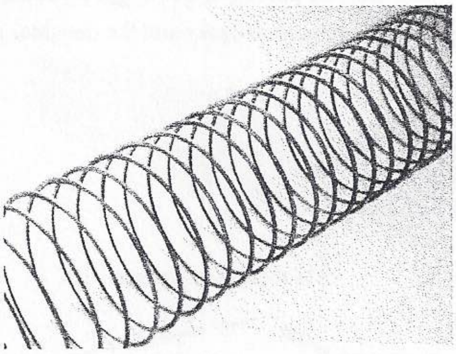
(b) Figure 9.2 shows a metal slinky spring.

Figure 9.2



(i) If a direct current passes through the spring, briefly explain whether the spring will be compressed or stretched due to magnetic force. (2 marks)

(ii) A student suggests that the spring will be compressed and stretched alternately due to magnetic force when an alternating current passes through. Briefly explain why he is wrong. (1 mark)

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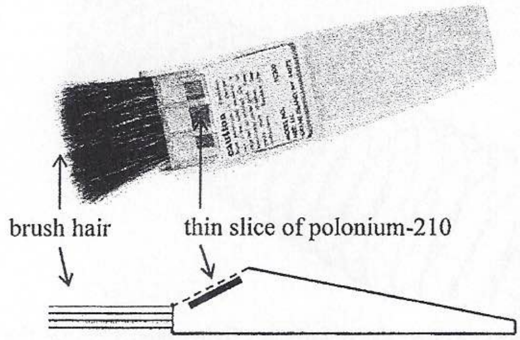
10. Dust may adhere to the surfaces of photos and films due to electrostatic attraction. To remove the dust effectively, a special brush with a thin slice of polonium-210 ($^{210}_{84}Po$) fixed near the brush hair as shown in Figure 10.1 may be used. Polonium-210 undergoes α decay and the daughter nucleus lead (Pb) is stable.

Figure 10.1



(a) Write a nuclear equation for the decay of polonium-210. (2 marks)

(b) Briefly explain how the α particles help clean the charged dust. (2 marks)

(c) Briefly explain why the polonium-210 slice must be fixed near to the brush hair. (1 mark)

*(d) The manufacturer recommends that the brush should be returned to the factory for replacement of the polonium-210 slice every year. Taking the activity of a newly replaced polonium-210 slice as 1 unit, find its activity after one year (365 days). Given: half-life of polonium-210 is 138 days. (2 marks)

END OF PAPER

Sources of materials used in this paper will be acknowledged in the booklet *HKDSE Question Papers* published by the Hong Kong Examinations and Assessment Authority at a later stage.

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List of data, formulae and relationships

Data

molar gas constant	$R = 8.31\ \text{J mol}^{-1}\ \text{K}^{-1}$	
Avogadro constant	$N_A = 6.02 \times 10^{23}\ \text{mol}^{-1}$	
acceleration due to gravity	$g = 9.81\ \text{m s}^{-2}$ (close to the Earth)	
universal gravitational constant	$G = 6.67 \times 10^{-11}\ \text{N m}^2\ \text{kg}^{-2}$	
speed of light in vacuum	$c = 3.00 \times 10^8\ \text{m s}^{-1}$	
charge of electron	$e = 1.60 \times 10^{-19}\ \text{C}$	
electron rest mass	$m_e = 9.11 \times 10^{-31}\ \text{kg}$	
permittivity of free space	$\varepsilon_0 = 8.85 \times 10^{-12}\ \text{C}^2\ \text{N}^{-1}\ \text{m}^{-2}$	
permeability of free space	$\mu_0 = 4\pi \times 10^{-7}\ \text{H m}^{-1}$	
atomic mass unit	$\text{u} = 1.661 \times 10^{-27}\ \text{kg}$	(1 u is equivalent to 931 MeV)
astronomical unit	$\text{AU} = 1.50 \times 10^{11}\ \text{m}$	
light year	$\text{ly} = 9.46 \times 10^{15}\ \text{m}$	
parsec	$\text{pc} = 3.09 \times 10^{16}\ \text{m} = 3.26\ \text{ly} = 206265\ \text{AU}$	
Stefan constant	$\sigma = 5.67 \times 10^{-8}\ \text{W m}^{-2}\ \text{K}^{-4}$	
Planck constant	$h = 6.63 \times 10^{-34}\ \text{J s}$	

Rectilinear motion

For uniformly accelerated motion :

$$v = u + at$$

$$s = ut + \frac{1}{2}at^2$$

$$v^2 = u^2 + 2as$$

Mathematics

Equation of a straight line	$y = mx + c$
Arc length	$= r\theta$
Surface area of cylinder	$= 2\pi rh + 2\pi r^2$
Volume of cylinder	$= \pi r^2 h$
Surface area of sphere	$= 4\pi r^2$
Volume of sphere	$= \frac{4}{3}\pi r^3$

For small angles, $\sin\theta \approx \tan\theta \approx \theta$ (in radians)

Astronomy and Space Science

$U = -\frac{GMm}{r}$	gravitational potential energy
$P = \sigma AT^4$	Stefan's law
$\left\lvert\frac{\Delta f}{f_0}\right\rvert \approx \frac{v}{c} \approx \left\lvert\frac{\Delta\lambda}{\lambda_0}\right\rvert$	Doppler effect

Energy and Use of Energy

$E = \frac{\Phi}{A}$	illuminance
$\frac{Q}{t} = \kappa\frac{A(T_H - T_C)}{d}$	rate of energy transfer by conduction
$U = \frac{\kappa}{d}$	thermal transmittance U-value
$P = \frac{1}{2}\rho Av^3$	maximum power by wind turbine

Atomic World

$\frac{1}{2}m_e v_{max}^2 = hf - \phi$	Einstein's photoelectric equation
$E_n = -\frac{1}{n^2}\left\{\frac{m_e e^4}{8h^2\varepsilon_0^2}\right\} = -\frac{13.6}{n^2}\text{eV}$	energy level equation for hydrogen atom
$\lambda = \frac{h}{p} = \frac{h}{mv}$	de Broglie formula
$\theta \approx \frac{1.22\lambda}{d}$	Rayleigh criterion (resolving power)

Medical Physics

$\theta \approx \frac{1.22\lambda}{d}$	Rayleigh criterion (resolving power)
$\text{power} = \frac{1}{f}$	power of a lens
$L = 10\log\frac{I}{I_0}$	intensity level (dB)
$Z = \rho c$	acoustic impedance
$\alpha = \frac{I_r}{I_0} = \frac{(Z_2 - Z_1)^2}{(Z_2 + Z_1)^2}$	intensity reflection coefficient
$I = I_0 e^{-\mu x}$	transmitted intensity through a medium

A1.	$E = mc\,\Delta T$	energy transfer during heating and cooling	D1.	$F = \dfrac{Q_1 Q_2}{4\pi\varepsilon_0 r^2}$	Coulomb's law
A2.	$E = l\,\Delta m$	energy transfer during change of state	D2.	$E = \dfrac{Q}{4\pi\varepsilon_0 r^2}$	electric field strength due to a point charge
A3.	$pV = nRT$	equation of state for an ideal gas	D3.	$E = \dfrac{V}{d}$	electric field between parallel plates (numerically)
A4.	$pV = \dfrac{1}{3} N m \overline{c^2}$	kinetic theory equation	D4.	$R = \dfrac{\rho l}{A}$	resistance and resistivity
A5.	$E_K = \dfrac{3RT}{2N_A}$	molecular kinetic energy	D5.	$R = R_1 + R_2$	resistors in series
			D6.	$\dfrac{1}{R} = \dfrac{1}{R_1} + \dfrac{1}{R_2}$	resistors in parallel
B1.	$F = m\dfrac{\Delta v}{\Delta t} = \dfrac{\Delta p}{\Delta t}$	force	D7.	$P = IV = I^2 R$	power in a circuit
B2.	moment $= F \times d$	moment of a force	D8.	$F = BQv \sin\theta$	force on a moving charge in a magnetic field
B3.	$E_P = mgh$	gravitational potential energy	D9.	$F = BIl \sin\theta$	force on a current-carrying conductor in a magnetic field
B4.	$E_K = \dfrac{1}{2} mv^2$	kinetic energy	D10.	$B = \dfrac{\mu_0 I}{2\pi r}$	magnetic field due to a long straight wire
B5.	$P = Fv$	mechanical power	D11.	$B = \dfrac{\mu_0 NI}{l}$	magnetic field inside a long solenoid
B6.	$a = \dfrac{v^2}{r} = \omega^2 r$	centripetal acceleration	D12.	$\varepsilon = N\dfrac{\Delta\Phi}{\Delta t}$	induced e.m.f.
B7.	$F = \dfrac{Gm_1 m_2}{r^2}$	Newton's law of gravitation	D13.	$\dfrac{V_s}{V_p} \approx \dfrac{N_s}{N_p}$	ratio of secondary voltage to primary voltage in a transformer
C1.	$\Delta y = \dfrac{\lambda D}{a}$	fringe width in double-slit interference	E1.	$N = N_0 e^{-kt}$	law of radioactive decay
C2.	$d \sin\theta = n\lambda$	diffraction grating equation	E2.	$t_{\frac{1}{2}} = \dfrac{\ln 2}{k}$	half-life and decay constant
C3.	$\dfrac{1}{u} + \dfrac{1}{v} = \dfrac{1}{f}$	equation for a single lens	E3.	$A = kN$	activity and the number of undecayed nuclei
			E4.	$\Delta E = \Delta mc^2$	mass-energy relationship