Surname		Other Names	
Centre Number		Candidate Number	
Candidate Signature			

Leave blank

General Certificate of Education
January 2006
Advanced Subsidiary Examination

PHYSICS (SPECIFICATION A) **PHA3/P**
Practical (Unit 3)

Tuesday 17 January 2006 1.30 pm to 3.15 pm

For this paper you must have:
- a calculator
- a pencil and ruler

Time allowed: 1 hour 45 minutes

Instructions
- Use blue or black ink or ball-point pen.
- Fill in the boxes at the top of this page.
- Answer **all** questions
- Answer questions in the spaces provided.
- Show all your working.
- Do all rough work in this book. Cross through any work you do not want marked.

Information
- The maximum mark for this paper is 30.
- The marks for questions are shown in brackets.
- A *Data Sheet* is provided on pages 3 and 4. You may wish to detach this perforated sheet at the start of the examination.
- You are expected to use a calculator where appropriate.
- You are advised to spend no more than 30 minutes on Question 1.
- You are provided with an A3 sheet, INSERT TO PHA3/P/TN, which will be required for Question 2.

For Examiner's Use			
Number	Mark	Number	Mark
1			
2			
Total (Column 1) →			
Total (Column 2) →			
Quality of Written Communication			
TOTAL			
Examiner's Initials			

www.theallpapers.com

Data Sheet

- A perforated Data Sheet is provided as pages 3 and 4 of this question paper.
- This sheet may be useful for answering some of the questions in the examination.
- You may wish to detach this sheet before you begin work.

www.theallpapers.com

Data Sheet

Fundamental constants and values

Quantity	*Symbol*	*Value*	*Units*
speed of light in vacuo	c	3.00×10^{8}	$\mathrm{m\ s^{-1}}$
permeability of free space	μ_0	$4\pi \times 10^{-7}$	$\mathrm{H\ m^{-1}}$
permittivity of free space	ε_0	8.85×10^{-12}	$\mathrm{F\ m^{-1}}$
charge of electron	e	1.60×10^{-19}	C
the Planck constant	h	6.63×10^{-34}	J s
gravitational constant	G	6.67×10^{-11}	$\mathrm{N\ m^{2}\ kg^{-2}}$
the Avogadro constant	N_A	6.02×10^{23}	$\mathrm{mol^{-1}}$
molar gas constant	R	8.31	$\mathrm{J\ K^{-1}\ mol^{-1}}$
the Boltzmann constant	k	1.38×10^{-23}	$\mathrm{J\ K^{-1}}$
the Stefan constant	σ	5.67×10^{-8}	$\mathrm{W\ m^{-2}\ K^{-4}}$
the Wien constant	α	2.90×10^{-3}	m K
electron rest mass (equivalent to 5.5×10^{-4}u)	m_e	9.11×10^{-31}	kg
electron charge/mass ratio	e/m_e	1.76×10^{11}	$\mathrm{C\ kg^{-1}}$
proton rest mass (equivalent to 1.00728u)	m_p	1.67×10^{-27}	kg
proton charge/mass ratio	e/m_p	9.58×10^{7}	$\mathrm{C\ kg^{-1}}$
neutron rest mass (equivalent to 1.00867u)	m_n	1.67×10^{-27}	kg
gravitational field strength	g	9.81	$\mathrm{N\ kg^{-1}}$
acceleration due to gravity	g	9.81	$\mathrm{m\ s^{-2}}$
atomic mass unit (1u is equivalent to 931.3 MeV)	u	1.661×10^{-27}	kg

Fundamental particles

Class	*Name*	*Symbol*	*Rest energy* /MeV
photon	photon	γ	0
lepton	neutrino	ν_e	0
		ν_μ	0
	electron	$e^{\pm}$	0.510999
	muon	$\mu^{\pm}$	105.659
mesons	pion	$\pi^{\pm}$	139.576
		π^{0}	134.972
	kaon	$K^{\pm}$	493.821
		K^{0}	497.762
baryons	proton	p	938.257
	neutron	n	939.551

Properties of quarks

Type	*Charge*	*Baryon number*	*Strangeness*
u	$+\frac{2}{3}$	$+\frac{1}{3}$	0
d	$-\frac{1}{3}$	$+\frac{1}{3}$	0
s	$-\frac{1}{3}$	$+\frac{1}{3}$	-1

Geometrical equations

arc length $= r\theta$

circumference of circle $= 2\pi r$

area of circle $= \pi r^2$

area of cylinder $= 2\pi rh$

volume of cylinder $= \pi r^2 h$

area of sphere $= 4\pi r^2$

volume of sphere $= \frac{4}{3}\pi r^3$

Mechanics and Applied Physics

$v = u + at$

$s = \left(\frac{u+v}{2}\right)t$

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

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

$F = \frac{\Delta(mv)}{\Delta t}$

$P = Fv$

$efficiency = \frac{power\ output}{power\ input}$

$\omega = \frac{v}{r} = 2\pi f$

$a = \frac{v^2}{r} = r\omega^2$

$I = \sum mr^2$

$E_k = \frac{1}{2} I\omega^2$

$\omega_2 = \omega_1 + \alpha t$

$\theta = \omega_1 t + \frac{1}{2}\alpha t^2$

$\omega_2^2 = \omega_1^2 + 2\alpha\theta$

$\theta = \frac{1}{2}(\omega_1 + \omega_2)t$

$T = I\alpha$

angular momentum $= I\omega$

$W = T\theta$

$P = T\omega$

angular impulse = change of angular momentum $= Tt$

$\Delta Q = \Delta U + \Delta W$

$\Delta W = p\Delta V$

$pV^{\gamma} =$ constant

work done per cycle = area of loop

input power = calorific value × fuel flow rate

indicated power as (area of p – V loop) × (no. of cycles/s) × (no. of cylinders)

friction power = indicated power – brake power

$efficiency = \frac{W}{Q_{in}} = \frac{Q_{in} - Q_{out}}{Q_{in}}$

maximum possible

$efficiency = \frac{T_H - T_C}{T_H}$

Fields, Waves, Quantum Phenomena

$g = \frac{F}{m}$

$g = -\frac{GM}{r^2}$

$g = -\frac{\Delta V}{\Delta x}$

$V = -\frac{GM}{r}$

$a = -(2\pi f)^2 x$

$v = \pm 2\pi f\sqrt{A^2 - x^2}$

$x = A\cos 2\pi ft$

$T = 2\pi\sqrt{\frac{m}{k}}$

$T = 2\pi\sqrt{\frac{l}{g}}$

$\lambda = \frac{\omega s}{D}$

$d\sin\theta = n\lambda$

$\theta \approx \frac{\lambda}{D}$

${}_1n_2 = \frac{\sin\theta_1}{\sin\theta_2} = \frac{c_1}{c_2}$

${}_1n_2 = \frac{n_2}{n_1}$

$\sin\theta_c = \frac{1}{n}$

$E = hf$

$hf = \phi + E_k$

$hf = E_1 - E_2$

$\lambda = \frac{h}{p} = \frac{h}{mv}$

$c = \frac{1}{\sqrt{\mu_0\varepsilon_0}}$

Electricity

$\epsilon = \frac{E}{Q}$

$\epsilon = I(R + r)$

$\frac{1}{R_T} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} + \cdots$

$R_T = R_1 + R_2 + R_3 + \cdots$

$P = I^2R$

$E = \frac{F}{Q} = \frac{V}{d}$

$E = \frac{1}{4\pi\varepsilon_0}\frac{Q}{r^2}$

$E = \frac{1}{2}QV$

$F = BIl$

$F = BQv$

$Q = Q_0 e^{-t/RC}$

$\Phi = BA$

www.theallpapers.com

$$magnitude\ of\ induced\ e.m.f. = N\frac{\Delta\Phi}{\Delta t}$$

$$I_{rms} = \frac{I_0}{\sqrt{2}}$$

$$V_{rms} = \frac{V_0}{\sqrt{2}}$$

Mechanical and Thermal Properties

$$the\ Young\ modulus = \frac{tensile\ stress}{tensile\ strain} = \frac{F}{A}\frac{l}{e}$$

$$energy\ stored = \tfrac{1}{2}Fe$$

$$\Delta Q = mc\,\Delta\theta$$

$$\Delta Q = ml$$

$$pV = \tfrac{1}{3}Nm\overline{c^2}$$

$$\tfrac{1}{2}m\overline{c^2} = \tfrac{3}{2}kT = \frac{3RT}{2N_A}$$

Nuclear Physics and Turning Points in Physics

$$force = \frac{eV_p}{d}$$

$$force = Bev$$

$$radius\ of\ curvature = \frac{mv}{Be}$$

$$\frac{eV}{d} = mg$$

$$work\ done = eV$$

$$F = 6\pi\eta rv$$

$$I = k\frac{I_0}{x^2}$$

$$\frac{\Delta N}{\Delta t} = -\lambda N$$

$$\lambda = \frac{h}{\sqrt{2meV}}$$

$$N = N_0 e^{-\lambda t}$$

$$T_{\frac{1}{2}} = \frac{\ln 2}{\lambda}$$

$$R = r_0 A^{\frac{1}{3}}$$

$$E = mc^2 = \frac{m_0c^2}{\left(1 - \frac{v^2}{c^2}\right)^{\frac{1}{2}}}$$

$$l = l_0\left(1 - \frac{v^2}{c^2}\right)^{\frac{1}{2}}$$

$$t = \frac{t_0}{\left(1 - \frac{v^2}{c^2}\right)^{\frac{1}{2}}}$$

Astrophysics and Medical Physics

Body	*Mass*/kg	*Mean radius*/m
Sun	2.00×10^{30}	7.00×10^{8}
Earth	6.00×10^{24}	6.40×10^{6}

1 astronomical unit = 1.50×10^{11} m

1 parsec = 206265 AU = 3.08×10^{16} m = 3.26 ly

1 light year = 9.45×10^{15} m

Hubble constant (H) = 65 km s^{-1} Mpc^{-1}

$$M = \frac{\text{angle subtended by image at eye}}{\text{angle subtended by object at unaided eye}}$$

$$M = \frac{f_o}{f_e}$$

$$m - M = 5\log\frac{d}{10}$$

$$\lambda_{max}T = \text{constant} = 0.0029\ \text{m K}$$

$$v = Hd$$

$$P = \sigma AT^4$$

$$\frac{\Delta f}{f} = \frac{v}{c}$$

$$\frac{\Delta\lambda}{\lambda} = -\frac{v}{c}$$

$$R_s \approx \frac{2GM}{c^2}$$

Medical Physics

$$power = \frac{1}{f}$$

$$\frac{1}{u} + \frac{1}{v} = \frac{1}{f} \quad \text{and} \quad m = \frac{v}{u}$$

$$intensity\ level = 10\log\frac{I}{I_0}$$

$$I = I_0 e^{-\mu x}$$

$$\mu_m = \frac{\mu}{\rho}$$

Electronics

Resistors

Preferred values for resistors (E24) Series: 1.0 1.1 1.2 1.3 1.5 1.6 1.8 2.0 2.2 2.4 2.7 3.0 3.3 3.6 3.9 4.3 4.7 5.1 5.6 6.2 6.8 7.5 8.2 9.1 ohms
and multiples that are ten times greater

$$Z = \frac{V_{rms}}{I_{rms}}$$

$$\frac{1}{C_T} = \frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3} + \cdots$$

$$C_T = C_1 + C_2 + C_3 + \cdots$$

$$X_C = \frac{1}{2\pi fC}$$

Alternating Currents

$$f = \frac{1}{T}$$

Operational amplifier

$$G = \frac{V_{out}}{V_{in}} \quad \text{voltage gain}$$

$$G = -\frac{R_f}{R_1} \quad \text{inverting}$$

$$G = 1 + \frac{R_f}{R_1} \quad \text{non-inverting}$$

$$V_{out} = -R_f\left(\frac{V_1}{R_1} + \frac{V_2}{R_2} + \frac{V_3}{R_3}\right) \quad \text{summing}$$

www.theallpapers.com

Turn over for the first question

www.theallpapers.com

LEAVE
MARGIN
BLANK

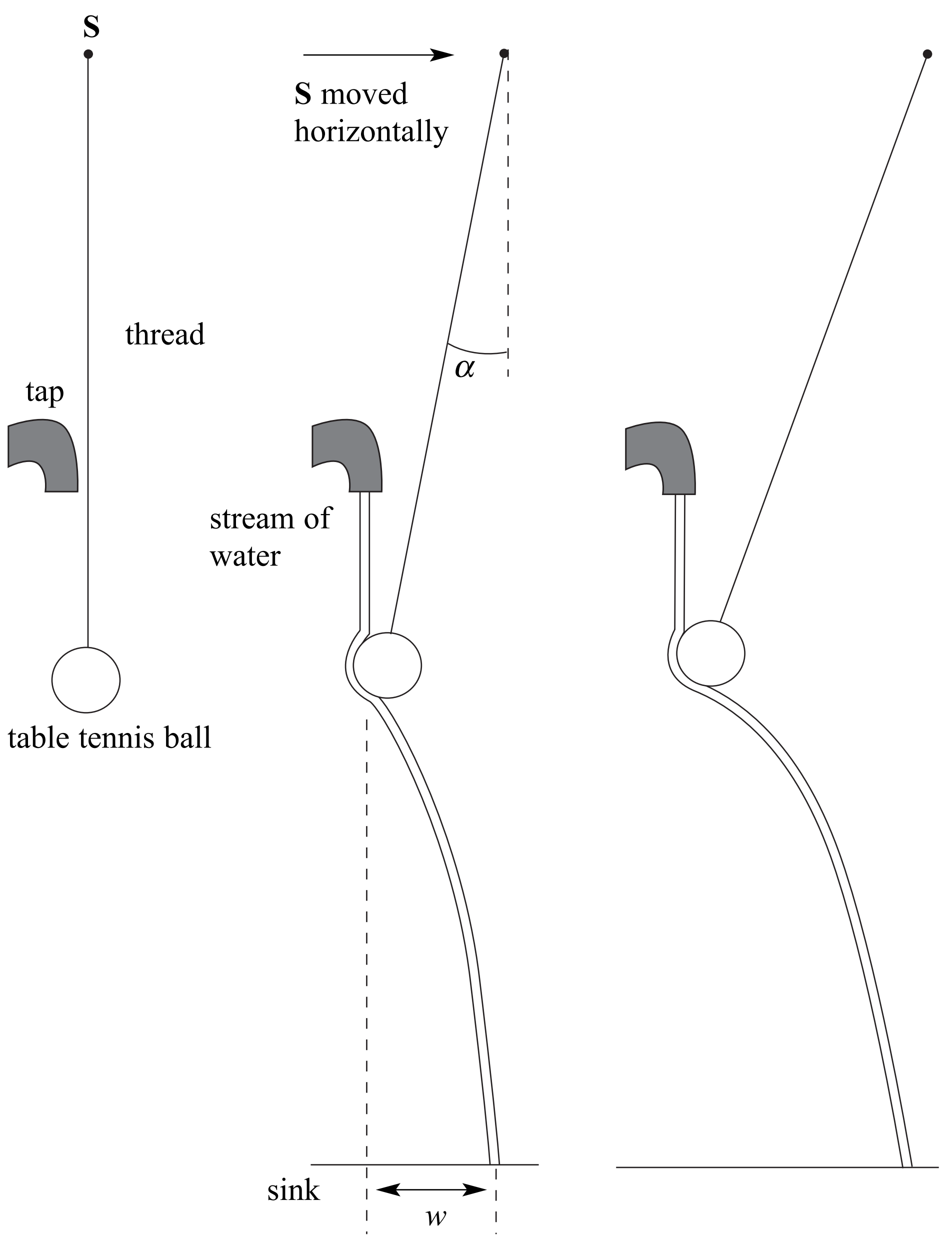
Answer **all** questions.

You are advised to spend no more than 30 minutes on Question 1.

1 Two physics students are shown an experiment in which a table tennis ball, suspended by a thread from a point **S**, is positioned under a vertical stream of water falling into a sink. When **S** is moved horizontally the ball remains under the stream. The sideways force pushing the ball towards the stream arises because the water flowing around the surface of the ball is accelerated.

As **S** is moved further in the same direction, the inclination of the thread to the vertical, α, and the horizontal displacement of the water stream at the sink, w, both increase, as shown in **Figure 1**.

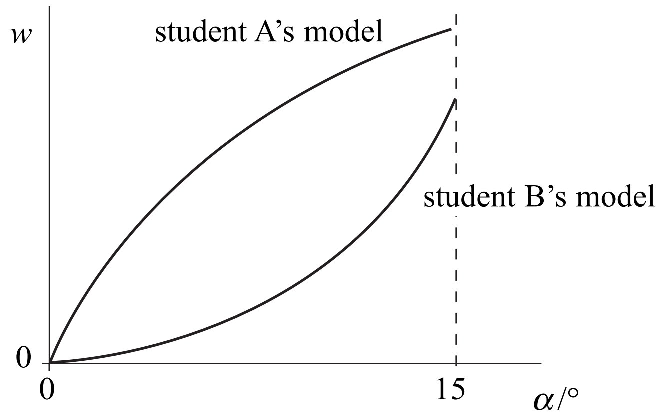
Figure 1



www.theallpapers.com

The students each use a computer to model the situation and to predict how w depends on α. Both models show that for the water streams that can be produced in their laboratory, the largest value of α will be no greater than 15°.
Student A's model shows w increasing at a decreasing rate as α is increased.
Student B's model shows w increasing at an increasing rate as α is increased.
These predictions are shown in **Figure 2**.

Figure 2



Design an experiment that the students could perform to discover if the predictions made by either of their computer models are accurate.

You should assume that the normal laboratory apparatus used in schools and colleges is available to the students.

- Identify the quantities you intend to measure and explain how you will measure them. You may wish to use the space below to draw a diagram to illustrate this part of your answer.
- Explain how you propose to use your measurements to determine whether either computer model correctly shows how w depends on α.
- List any factors you will need to control and explain how you will do this.
- Identify any difficulties you might encounter in obtaining reliable results and explain how these could be overcome.

Write your answer to Question 1 on pages **8** and **9** of this booklet. *(8 marks)*

www.theallpapers.com

LEAVE MARGIN BLANK

www.theallpapers.com

LEAVE MARGIN BLANK

8

www.theallpapers.com

LEAVE
MARGIN
BLANK

2 For Question 2, there is an A3 sheet, (INSERT TO PHA3/P/TN), provided. This sheet will not be sent to the examiner but should be left with the paper at the end of the examination. If you require a further copy of this sheet, ask the supervisor.

You are to investigate the deviation of a light ray passing through a semicircular transparent block.

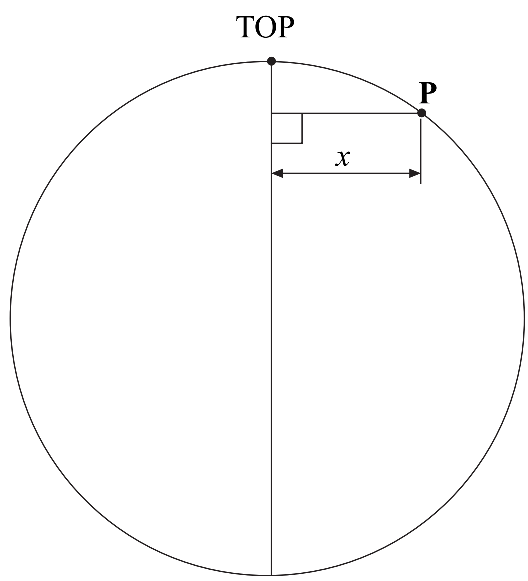
(a) You are provided with a large sheet of paper showing a diagram of a circle. A diameter of the circle has been marked on the diagram.

(i) Measure and record below the diameter, *D*, of this circle.

D = ...

(ii) With the point marked TOP furthest from you, measure and record the perpendicular distance, *x*, between the point **P** on the circle and the marked diameter, as shown in **Figure 3**.

Figure 3



x = ...

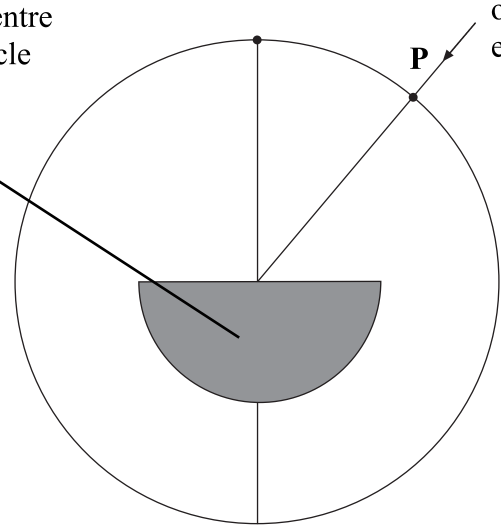
(2 marks)

www.theallpapers.com

LEAVE
MARGIN
BLANK

(b) Position the semicircular block as shown in **Figure 4** so that the centre of the flat edge of the block is perpendicular to the marked diameter. Adjust the position of the block until the centre of the flat edge of the block is at the centre of the circle.

Figure 4

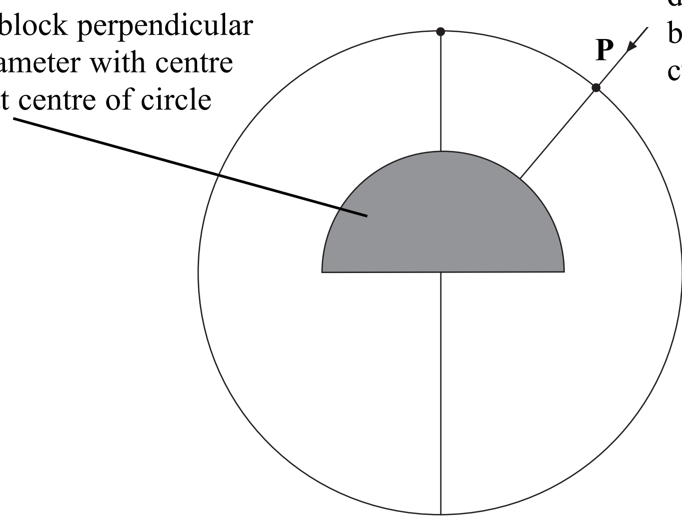


Position the ray box so that a ray of light passes through point **P** and is then incident on the centre of the flat edge of the block.
Mark on the diagram the path of the ray emerging from the curved edge of the block.
Extend this line to reach the circle.
Measure and record the perpendicular distance, y, between the point where the emergent ray reaches the circle and the marked diameter.

y = ...

Rotate the block to the position shown in **Figure 5**. Note that the centre of the flat edge of the block should still be perpendicular to the marked diameter and the centre of the flat edge of the block should remain at the centre of the circle.

Figure 5



Question 2 continues on the next page

www.theallpapers.com

LEAVE MARGIN BLANK

Mark on the diagram the path of the ray emerging from the flat edge of the block.
Extend this line to reach the circle.
Measure and record the perpendicular distance, z, between the point where the emergent ray reaches the circle and the marked diameter.

z = ...

Replace the block as in **Figure 4** and reposition the ray box so that the ray of light now enters the circle **between** point **P** and the point marked TOP on the marked diameter.
Ensure that the ray is once again incident on the centre of the flat edge of the block.
Repeating the procedure as before, measure and record additional values of y corresponding to **five smaller** values of x.
Reposition the block as in **Figure 5** and repeat the procedure to measure and record values of z corresponding to the **same five smaller** values of x.
You may ask the supervisor for additional sheets of paper, if required.

Record all your measurements and observations below.

(6 marks)

(c) Using the grid on **page 13**, plot a graph with z on the vertical axis and y on the horizontal axis. *(5 marks)*

(d) Measure and record the gradient, G, of your graph.

G = ... *(3 marks)*

www.theallpapers.com

www.theallpapers.com

LEAVE MARGIN BLANK

(e) (i) Explain the procedure you used to position the semicircular block as in **Figure 4**.

....

....

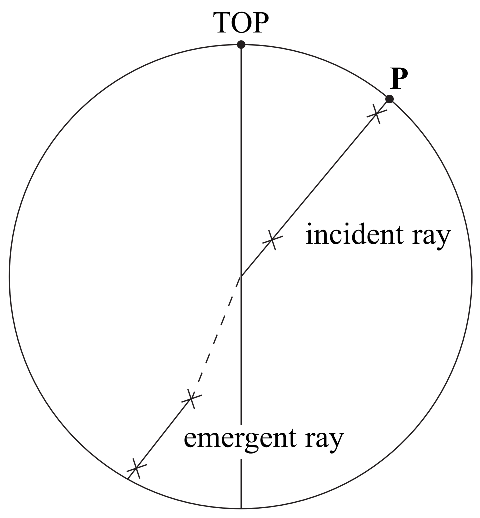
....

....

....

(ii) A student, performing the experiment, attempts to arrange the block as shown in **Figure 4**, so that light passes in through the flat edge and traces the paths of the incident and emergent rays to and from the block. When the block is removed, the student draws a line (shown dotted in **Figure 6**) to join the incident and emergent rays.

Figure 6



Assuming that the block was of constant radius, state and explain the mistake the student has made.

....

....

....

....

....

(6 marks)

22

END OF QUESTIONS

www.theallpapers.com

There are no questions printed on this page

www.theallpapers.com

There are no questions printed on this page

Copyright © 2006 AQA and its licensors. All rights reserved.

www.theallpapers.com

General Certificate of Education
January 2006

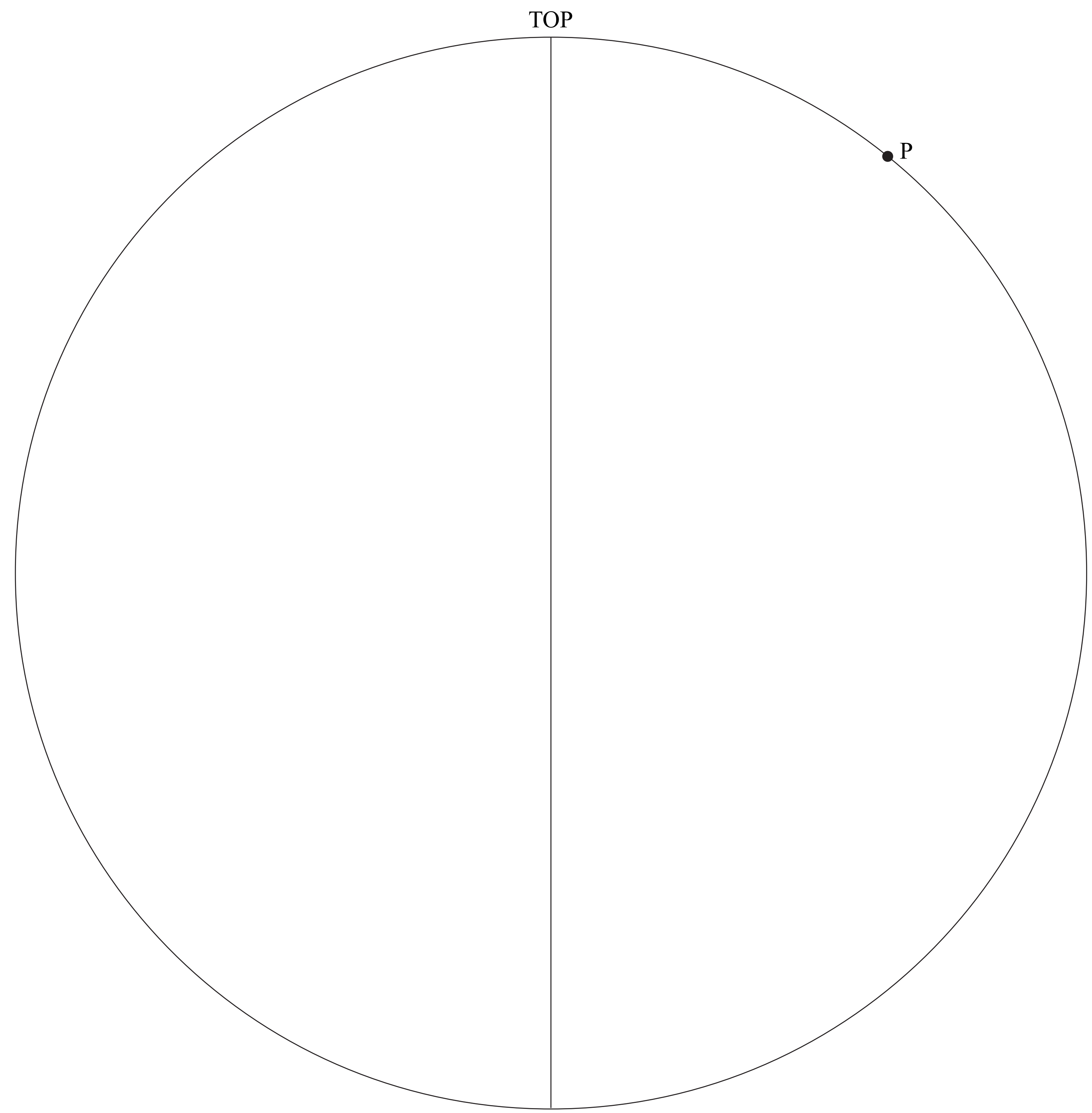
PHYSICS (SPECIFICATION A) **PHA3/P**
Practical (Unit 3)

Insert

For use in Question 2

www.theallpapers.com

For use in Question 2



www.theallpapers.com