

Surname						Other Names					
Centre Number						Candidate Number					
Candidate Signature											

For Examiner's Use
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General Certificate of Education  
 June 2007  
 Advanced Subsidiary Examination



ASSESSMENT and  
 QUALIFICATIONS  
 ALLIANCE

**PHYSICS (SPECIFICATION A)**  
**Unit 2 Mechanics and Molecular Kinetic Theory**

**PA02**

Friday 8 June 2007 9.00 am to 10.00 am

<p><b>For this paper you must have:</b></p> <ul style="list-style-type: none"> <li>• a calculator</li> <li>• a pencil and a ruler.</li> </ul>
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Time allowed: 1 hour

**Instructions**

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

**Information**

- The maximum mark for this paper is 50.
- Two of these marks will be awarded for using good English, organising information clearly and using specialist vocabulary where appropriate.
- The marks for questions are shown in brackets.
- **A Data Sheet is provided on pages 3 and 4. Please do not attempt to detach this sheet at the start of the examination as this page is not perforated.**
- Questions 2(d) and 3(b) should be answered in continuous prose. In these questions you will be marked on your ability to use good English, to organise information clearly and to use specialist vocabulary where appropriate.

For Examiner's Use			
Question	Mark	Question	Mark
1			
2			
3			
4			
5			
6			
Total (Column 1)		→	
Total (Column 2)		→	
Quality of Written Communication			
TOTAL			
Examiner's Initials			



**Data Sheet**

- A *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.
- Please do not attempt to remove the data sheet as the page is not perforated.



Fundamental constants and values				Mechanics and Applied Physics	Fields, Waves, Quantum Phenomena
<i>Quantity</i>	<i>Symbol</i>	<i>Value</i>	<i>Units</i>		
speed of light in vacuo	$c$	$3.00 \times 10^8$	$\text{m s}^{-1}$	$v = u + at$	$g = \frac{F}{m}$
permeability of free space	$\mu_0$	$4\pi \times 10^{-7}$	$\text{H m}^{-1}$	$s = \left(\frac{u+v}{2}\right)t$	$g = -\frac{GM}{r^2}$
permittivity of free space	$\epsilon_0$	$8.85 \times 10^{-12}$	$\text{F m}^{-1}$	$s = ut + \frac{at^2}{2}$	$g = -\frac{\Delta V}{\Delta x}$
charge of electron	$e$	$1.60 \times 10^{-19}$	C	$v^2 = u^2 + 2as$	$V = -\frac{GM}{r}$
the Planck constant	$h$	$6.63 \times 10^{-34}$	J s	$F = \frac{\Delta(mv)}{\Delta t}$	$a = -(2\pi f)^2 x$
gravitational constant	$G$	$6.67 \times 10^{-11}$	$\text{N m}^2 \text{kg}^{-2}$	$P = Fv$	$v = \pm 2\pi f \sqrt{A^2 - x^2}$
the Avogadro constant	$N_A$	$6.02 \times 10^{23}$	$\text{mol}^{-1}$	$\text{efficiency} = \frac{\text{power output}}{\text{power input}}$	$x = A \cos 2\pi ft$
molar gas constant	$R$	8.31	$\text{J K}^{-1} \text{mol}^{-1}$	$\omega = \frac{v}{r} = 2\pi f$	$T = 2\pi \sqrt{\frac{m}{k}}$
the Boltzmann constant	$k$	$1.38 \times 10^{-23}$	$\text{J K}^{-1}$	$a = \frac{v^2}{r} = r\omega^2$	$T = 2\pi \sqrt{\frac{L}{g}}$
the Stefan constant	$\sigma$	$5.67 \times 10^{-8}$	$\text{W m}^{-2} \text{K}^{-4}$	$I = \sum mr^2$	$\lambda = \frac{\omega s}{D}$
the Wien constant	$\alpha$	$2.90 \times 10^{-3}$	m K	$E_k = \frac{1}{2} I\omega^2$	$d \sin \theta = n\lambda$
electron rest mass	$m_e$	$9.11 \times 10^{-31}$	kg	$\omega_2 = \omega_1 + at$	$\theta \approx \frac{\lambda}{D}$
(equivalent to $5.5 \times 10^{-4}u$ )				$\theta = \omega_1 t + \frac{1}{2} at^2$	${}_1n_2 = \frac{\sin \theta_1}{\sin \theta_2} = \frac{c_1}{c_2}$
electron charge/mass ratio	$e/m_e$	$1.76 \times 10^{11}$	$\text{C kg}^{-1}$	$\omega_2^2 = \omega_1^2 + 2\alpha\theta$	${}_1n_2 = \frac{n_2}{n_1}$
proton rest mass	$m_p$	$1.67 \times 10^{-27}$	kg	$\theta = \frac{1}{2} (\omega_1 + \omega_2)t$	$\sin \theta_c = \frac{1}{n}$
(equivalent to 1.00728u)				$T = I\alpha$	$E = hf$
proton charge/mass ratio	$e/m_p$	$9.58 \times 10^7$	$\text{C kg}^{-1}$	<i>angular momentum</i> = $I\omega$	$hf = \phi + E_k$
neutron rest mass	$m_n$	$1.67 \times 10^{-27}$	kg	$W = T\theta$	$hf = E_1 - E_2$
(equivalent to 1.00867u)				$P = T\omega$	$\lambda = \frac{h}{p} = \frac{h}{mv}$
gravitational field strength	$g$	9.81	$\text{N kg}^{-1}$	<i>angular impulse</i> = change of <i>angular momentum</i> = $Tt$	$c = \frac{1}{\sqrt{\mu_0 \epsilon_0}}$
acceleration due to gravity	$g$	9.81	$\text{m s}^{-2}$	$\Delta Q = \Delta U + \Delta W$	<b>Electricity</b>
atomic mass unit	$u$	$1.661 \times 10^{-27}$	kg	$\Delta W = p\Delta V$	$\epsilon = \frac{E}{Q}$
(1u is equivalent to 931.3 MeV)				$pV^\gamma = \text{constant}$	$\epsilon = I(R + r)$
<b>Fundamental particles</b>				<i>work done per cycle</i> = area of loop	$\frac{1}{R_T} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} + \dots$
<i>Class</i>	<i>Name</i>	<i>Symbol</i>	<i>Rest energy</i>	<i>input power</i> = calorific value $\times$ fuel flow rate	$R_T = R_1 + R_2 + R_3 + \dots$
			/MeV	<i>indicated power</i> as (area of $p - V$ loop) $\times$ (no. of cycles/s) $\times$ (no. of cylinders)	$P = I^2 R$
photon	photon	$\gamma$	0	<i>friction power</i> = indicated power - brake power	$E = \frac{F}{Q} = \frac{V}{d}$
lepton	neutrino	$\nu_e$	0	$\text{efficiency} = \frac{W}{Q_{in}} = \frac{Q_{in} - Q_{out}}{Q_{in}}$	$E = \frac{1}{4\pi\epsilon_0} \frac{Q}{r^2}$
		$\nu_\mu$	0	<i>maximum possible efficiency</i> = $\frac{T_H - T_C}{T_H}$	$E = \frac{1}{2} QV$
		electron	$e^\pm$	0.510999	
mesons	pion	$\mu^\pm$	105.659		$F = BQv$
		$\pi^\pm$	139.576		$Q = Q_0 e^{-t/RC}$
		$\pi^0$	134.972		$\Phi = BA$
baryons	kaon	$K^\pm$	493.821		
		$K^0$	497.762		
		proton	$p$	938.257	
	neutron	$n$	939.551		
<b>Properties of quarks</b>					
<i>Type</i>	<i>Charge</i>	<i>Baryon number</i>	<i>Strangeness</i>		
u	$+\frac{2}{3}$	$+\frac{1}{3}$	0		
d	$-\frac{1}{3}$	$+\frac{1}{3}$	0		
s	$-\frac{1}{3}$	$+\frac{1}{3}$	-1		
<b>Geometrical equations</b>					
<i>arc length</i> = $r\theta$					
<i>circumference of circle</i> = $2\pi r$					
<i>area of circle</i> = $\pi r^2$					
<i>area of cylinder</i> = $2\pi rh$					
<i>volume of cylinder</i> = $\pi r^2 h$					
<i>area of sphere</i> = $4\pi r^2$					
<i>volume of sphere</i> = $\frac{4}{3}\pi r^3$					

$$\text{magnitude of induced emf} = N \frac{\Delta\Phi}{\Delta t}$$

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

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

### Mechanical and Thermal Properties

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

$$\text{energy stored} = \frac{1}{2} Fe$$

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

$$\Delta Q = ml$$

$$pV = \frac{1}{3} Nmc^2$$

$$\frac{1}{2} mc^2 = \frac{3}{2} kT = \frac{3RT}{2N_A}$$

### Nuclear Physics and Turning Points in Physics

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

$$\text{force} = Bev$$

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

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

$$\text{work done} = eV$$

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

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

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

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

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

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

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

$$E = mc^2 = \frac{m_0 c^2}{\left(1 - \frac{v^2}{c^2}\right)^{\frac{1}{2}}}$$

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

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

### Astrophysics and Medical Physics

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

$$1 \text{ astronomical unit} = 1.50 \times 10^{11} \text{ m}$$

$$1 \text{ parsec} = 206265 \text{ AU} = 3.08 \times 10^{16} \text{ m} = 3.26 \text{ ly}$$

$$1 \text{ light year} = 9.45 \times 10^{15} \text{ m}$$

$$\text{Hubble constant } (H) = 65 \text{ kms}^{-1} \text{ Mpc}^{-1}$$

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

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

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

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

$$v = Hd$$

$$P = \sigma AT^4$$

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

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

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

### Medical Physics

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

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

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

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

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

### 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

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

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

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

$$X_C = \frac{1}{2\pi f C}$$

### Alternating Currents

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

### Operational amplifier

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

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

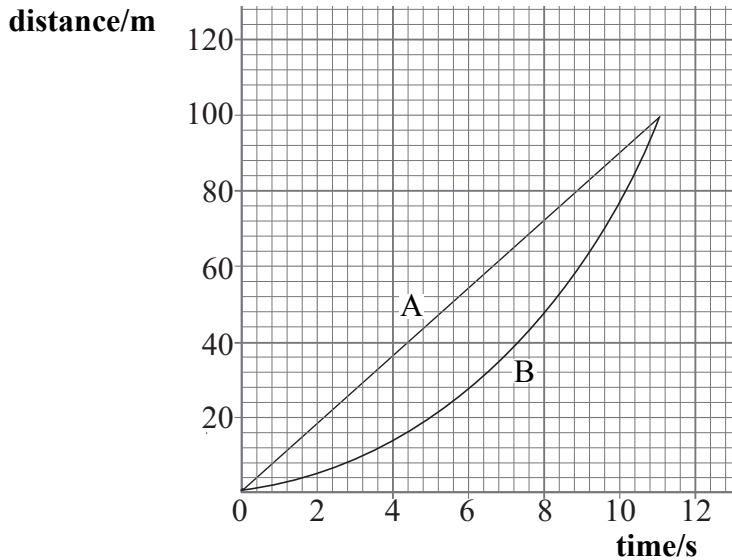
$$G = 1 + \frac{R_f}{R_1} \text{ non-inverting}$$

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



Answer **all** questions.

1 The distance-time graphs for two runners, A and B, in a 100 m race are shown.



(a) Explain how the graph shows that athlete B accelerates throughout the race.

.....  
 .....  
 (1 mark)

(b) Estimate the maximum distance between the athletes.

.....  
 (1 mark)

(c) Calculate the speed of athlete A during the race.

.....  
 (1 mark)

(d) The acceleration of athlete B is uniform for the duration of the race.

(i) State what is meant by uniform acceleration.

.....

(ii) Calculate the acceleration of athlete B.

.....

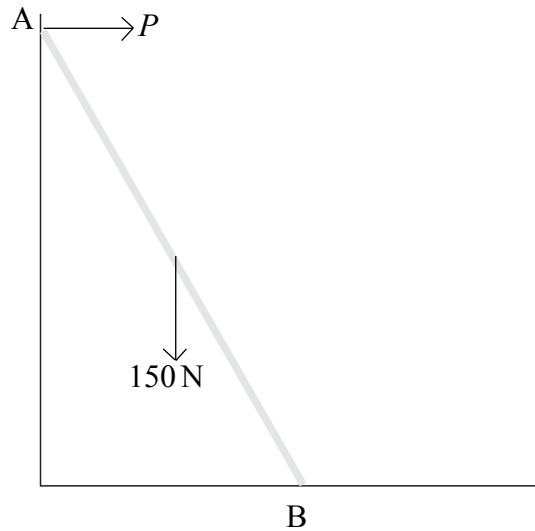
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(3 marks)



- 2 **Figure 1** shows two of the forces acting on a uniform ladder resting against a smooth vertical wall.

**Figure 1**



The ladder is  $6.0\text{ m}$  long and has a weight of  $150\text{ N}$ . The horizontal force,  $P$ , exerted on the ladder by the wall is  $43\text{ N}$ . Force  $Q$  (not shown) is the force the ground exerts on the ladder at B.

- (a) Explain why the force,  $Q$  must have

- (i) a vertical component,

.....  
 .....

- (ii) a horizontal component.

.....  
 .....

*(2 marks)*

- (b) Draw an arrow on the diagram to represent the force  $Q$ .

*(1 mark)*



(c) State the

(i) horizontal component of  $Q$ , .....

(ii) vertical component of  $Q$ . .....

(2 marks)

(d) State and explain the effect on force  $Q$  if a person stands on the bottom of the ladder and the direction of  $P$  is unchanged.

You may be awarded additional marks to those shown in brackets for the quality of written communication in your answer.

.....  
.....  
.....  
.....

(3 marks)

**Turn over for the next question**

<b>8</b>



3 A cylinder of fixed volume  $8.2 \times 10^{-3} \text{ m}^3$  contains gas at a temperature of 295 K and a pressure of  $4.2 \times 10^5 \text{ Pa}$ .

(a) Calculate

(i) the amount of gas in the cylinder in moles,

.....  
.....

(ii) the average kinetic energy of the gas molecules.

.....  
.....

*(3 marks)*

(b) The temperature of the gas in the cylinder is decreased.

You may be awarded additional marks to those shown in brackets for the quality of written communication in your answer.

(i) How does this change affect the motion of the gas molecules?

.....  
.....  
.....

(ii) State and explain, using the kinetic theory, the effect this has on the pressure of the gas.

.....  
.....  
.....

*(4 marks)*





- (c) Another cylinder of the same volume contains a gas at the same temperature and pressure as the original gas but whose molecules have a greater mass. Explain why the amount of energy required to raise the temperature of both gases by the same amount is identical.

.....

.....

.....

*(2 marks)*

**Turn over for the next question**

9
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4 Ice of mass 22 g at temperature  $-12\text{ }^{\circ}\text{C}$  is taken from a freezer and placed in a polystyrene cup containing water at a temperature  $22\text{ }^{\circ}\text{C}$ .

specific heat capacity of ice =  $2100\text{ J kg}^{-1}\text{ K}^{-1}$   
specific latent heat of fusion of ice =  $3.3 \times 10^5\text{ J kg}^{-1}$

(a) Calculate the quantity of heat needed

(i) to raise the temperature of the ice from  $-12\text{ }^{\circ}\text{C}$  to  $0\text{ }^{\circ}\text{C}$ ,

.....  
.....

(ii) to change the ice to water without an increase in temperature.

.....  
.....

(3 marks)

(b) The temperature of the water in the cup falls after the ice has been added.

specific heat capacity of water =  $4200\text{ J kg}^{-1}\text{ K}^{-1}$

(i) Calculate the mass of the water in the cup if the lowest temperature reached by the water is  $8\text{ }^{\circ}\text{C}$ .

.....  
.....  
.....

(ii) State an assumption you have made in part (b)(i).

.....  
.....

(4 marks)

7



5 An athlete performs an experiment to measure the power developed as he runs up a flight of stairs. The athlete makes the assumption that the work done in climbing the stairs is equal to the gain in potential energy.

(i) State the measurements that would be needed to find the power developed by the athlete.

.....  
.....  
.....  
.....

(ii) Show how the measurements would be used to calculate the power developed as the athlete runs up the stairs.

.....  
.....  
.....  
.....  
.....

(iii) Explain why the power calculated by the athlete is likely to be less than the power actually developed.

.....  
.....  
.....

*(8 marks)*

<b>8</b>



- 6 (a) State the principle of moments.

.....

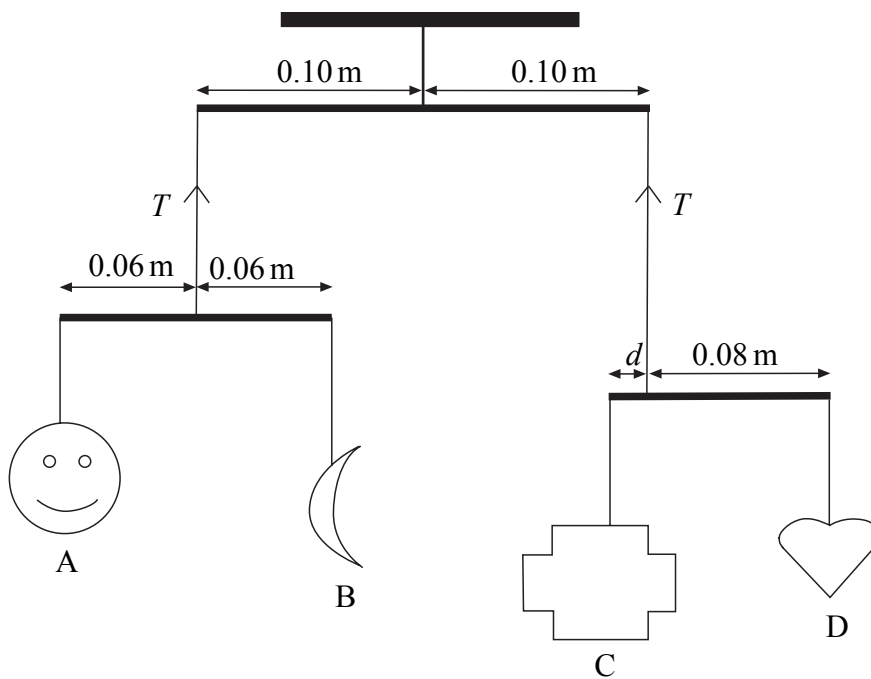
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(2 marks)

Figure 2 shows a child's mobile in equilibrium.

Figure 2



A piece of cotton thread is attached to the rod supporting objects A and B and another piece of cotton thread supports the rod holding objects C and D. The tension in the cotton threads is  $T$  and all the rods are horizontal.

- (b) (i) Complete the following table assuming the weights of the rods are negligible.

weight of object A /N	weight of object B /N	weight of object C /N	weight of object D /N
0.40			0.10



(ii) Calculate the distance,  $d$ .

.....  
.....

(iii) Calculate the magnitude of  $T$ .

.....  
*(5 marks)*

(c) Object A becomes detached and falls to the ground. State and explain the initial effect on

(i) the rod holding objects A and B,

.....  
.....

(ii) the rod holding objects C and D,

.....  
.....

(iii) the rod closest to the top of the mobile.

.....  
.....  
*(3 marks)*

**Quality of Written Communication** (2marks)

**END OF QUESTIONS**

**10**

**2**



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