Surname		Other Names	
Centre Number		Candidate Number	
Candidate Signature			

For Examiner's Use

General Certificate of Education
June 2008
Advanced Subsidiary Examination

ASSESSMENT and QUALIFICATIONS ALLIANCE

PHYSICS (SPECIFICATION A) **PA02**
Unit 2 Mechanics and Molecular Kinetic Theory

Thursday 22 May 2008 1.30 pm to 2.30 pm

For this paper you must have:
- a calculator
- a pencil and a ruler
- a data sheet insert.

Time allowed: 1 hour

Instructions
- Use black ink or a black ball-point pen.
- Fill in the boxes at the top of this page.
- Answer **all** questions.
- You must answer the questions in the spaces provided. Answers written in margins or on blank pages will not be marked.
- 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. This includes up to 2 marks for the Quality of Written Communication.
- The marks for questions are shown in brackets.
- A *Data Sheet* is provided as a loose insert to this question paper.
- Questions 1(c) and 3(a) 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			

Answer **all** questions in the spaces provided.

1 (a) (i) State **two** conditions necessary for an object to be in equilibrium.

....

....

....

....

1 (a) (ii) For each condition state the consequence if the condition is not met.

....

....

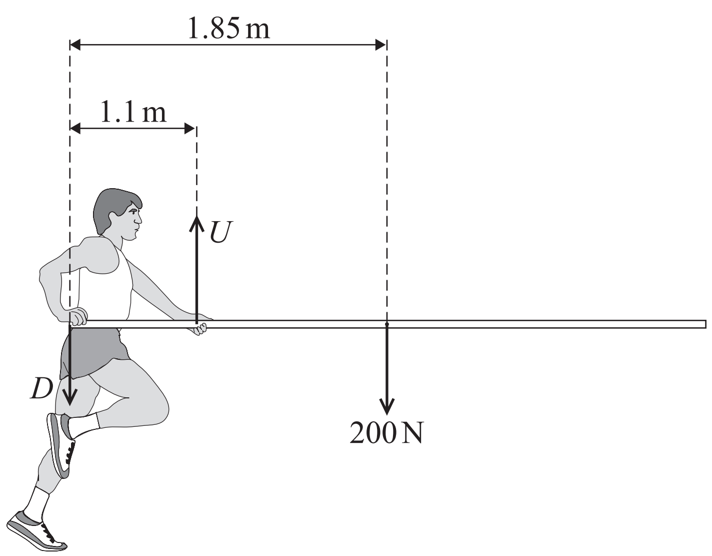
....

....

(4 marks)

Figure 1 shows a pole vaulter holding a uniform pole horizontally. He keeps the pole in equilibrium by exerting an upward force, U, with his leading hand, and a downward force, D, with his trailing hand.

Figure 1



weight of pole = 200 N
length of pole = 3.7 m

Areas outside the box will not be scanned for marking

1 (b) Calculate for the situation shown in **Figure 1**,

1 (b) (i) the force, *U*,

....

....

1 (b) (ii) the force, *D*.

....

....

....

(3 marks)

1 (c) Explain the effect on the magnitudes of *U* and *D* if the vaulter moves his leading hand closer to the centre of gravity of the pole and the pole is still in equilibrium.

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

....

....

....

....

....

....

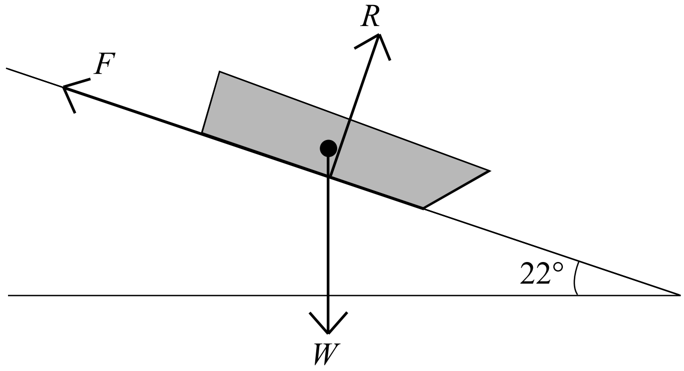
(3 marks)

10

Turn over for the next question

2 **Figure 2** shows a sledge moving down a slope at constant velocity.
The angle of the slope is 22°.

Figure 2



The three forces acting on the sledge are weight, W, friction, F, and the normal reaction force, R, of the ground on the sledge.

2 (a) With reference to an appropriate law of motion, explain why the sledge is moving at constant velocity.

....

....

....

....

....

....

(2 marks)

2 (b) The mass of the sledge is 4.5 kg. Calculate the component of W,

2 (b) (i) parallel to the slope,

....

....

....

2 (b) (ii) perpendicular to the slope,

....

....

....
(2 marks)

2 (c) State the values of *F* and *R*.

F ....

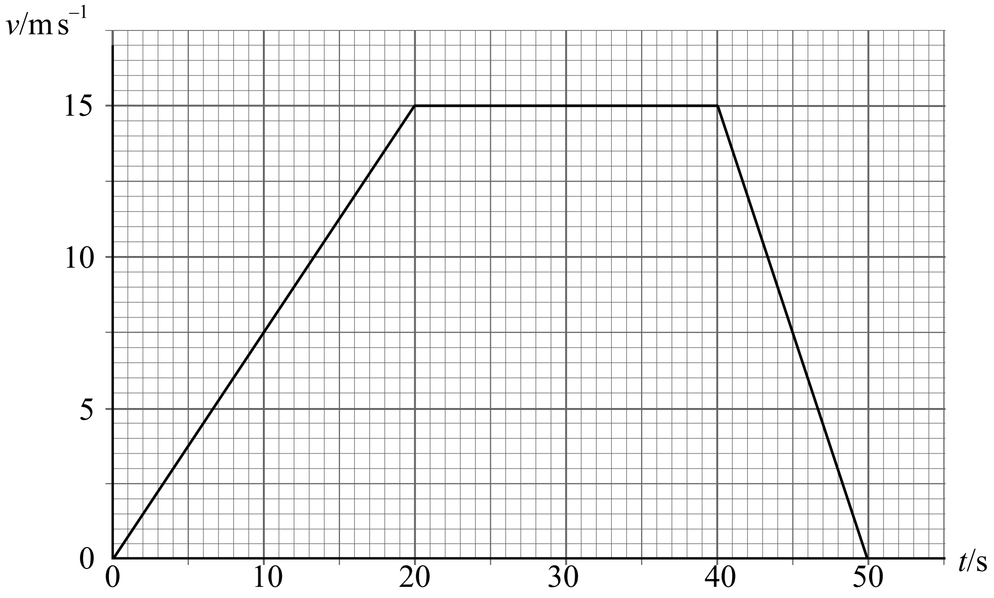
R ....
(2 marks)

6

Turn over for the next question

Areas outside the box will not be scanned for marking

3 The graph shows how the velocity, v, of a car varies with time, t.



3 (a) Describe the motion of the car for the 50 s period.

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

....

....

....

....

....

....

(3 marks)

3 (b) The mass of the car is 1200 kg. Calculate for the first 20 s of motion,

3 (b) (i) the change in momentum of the car,

....

....

....

....

3 (b) (ii) the rate of change of momentum,

....

....

3 (b) (iii) the distance travelled.

....

....

(4 marks)

7

Turn over for the next question

4 A kettle, rated at 2.5 kW, is used to raise the temperature of 1.2 kg of water from 20°C to 100°C and then convert some of the water to steam.

specific heat capacity of water = $4200\,\mathrm{J\,kg^{-1}\,K^{-1}}$
specific latent heat of vaporisation of water = $2.3 \times 10^{6}\,\mathrm{J\,kg^{-1}}$

4 (a) Calculate

4 (a) (i) the time taken to raise the temperature of the water from 20° C to 100° C,

....

....

....

....

4 (a) (ii) the additional time taken for the kettle to convert 10% of the water to steam.

....

....

....

(4 marks)

4 (b) State **two** reasons why in practice, the actual time taken in part 4(a)(i) will be longer.

....

....

....

....

(2 marks)

6

5 (a) 6.7 mol of an ideal gas in a rigid container exerts a pressure of 110 kPa at a temperature of 25°C.

5 (a) (i) Calculate the volume of the container.

....

....

....

5 (a) (ii) Calculate the average kinetic energy of a molecule of the gas.

....

....

....

5 (a) (iii) Deduce the pressure exerted by the gas if the average kinetic energy of the gas molecules is doubled.

....

....

....

(5 marks)

5 (b) Two of the assumptions about the behaviour of the molecules of an ideal gas are that they move with *random motion* and make *elastic collisions* with the walls of the container.

State and explain what is meant by

5 (b) (i) random motion,

....

....

....

Question 5 continues on the next page

Areas outside the box will not be scanned for marking

5 (b) (ii) elastic collisions.

....

....

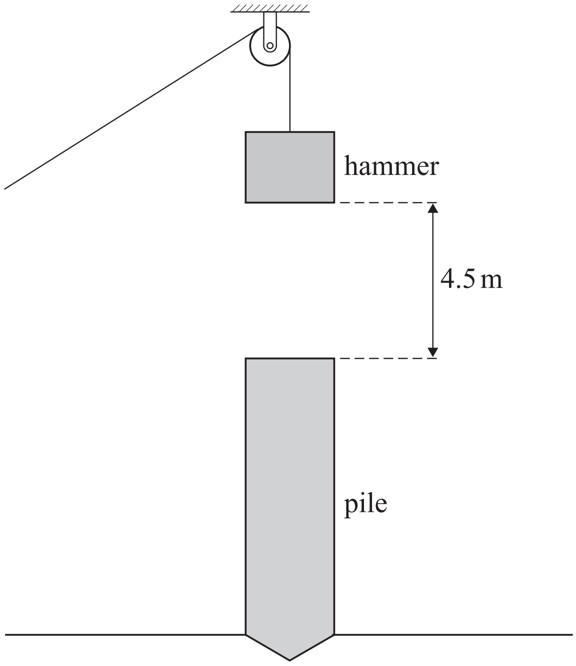
....

(3 marks)

8

6 A pile driver is used to drive cylindrical poles, called piles, into the ground so that they form the foundations of a building. **Figure 3** shows a possible arrangement for a pile driver. The hammer is held above the pile and then released so that it falls freely under gravity, until it strikes the top of the pile.

Figure 3



6 (a) State the main energy changes that take place as the hammer is falling.

....

....

....

(1 mark)

6 (b) The hammer has a mass of 250 kg and falls 4.5 m before striking the pile. After impact the hammer and pile move downwards together.
Calculate

6 (b) (i) the speed of the hammer just before impact,

....

....

6 (b) (ii) the momentum of the hammer just before the impact,

....

....

Question 6 continues on the next page

6 (b) (iii) the speed of the hammer and pile immediately after impact if the mass of the pile is 2000 kg.

....

....

....

(4 marks)

6 (c) After an impact the hammer and the pile move so that the pile sinks into the ground to a depth of 0.25 m.

Calcuate

6 (c) (i) the loss of kinetic energy of the hammer and pile,

....

....

....

6 (c) (ii) the average frictional force the ground exerts on the pile while bringing it to rest.

....

....

....

(4 marks)

6 (d) The process is repeated several times and each time the hammer is raised 4.5 m above the pile. Suggest why the extra depth of penetration is likely to decrease with each impact.

....

....

(2 marks)

11

Quality of Written Communication *(2 marks)*

2

END OF QUESTIONS

General Certificate of Education
June 2008
Advanced Subsidiary Examination

PHYSICS (SPECIFICATION A) **PA02**
Unit 2 Mechanics and Molecular Kinetic Theory
Data Sheet

ASSESSMENT and QUALIFICATIONS ALLIANCE

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

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

$\epsilon = I(R + r)$

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

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

$P = I^2R$

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

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

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

$F = BIl$

$F = BQv$

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

$\Phi = BA$

Turn over ▶

This insert should **not** be sent to the examiner magnitude of induced emf $= N \frac{\Delta \Phi}{\Delta t}$

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

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

Mechanical and Thermal Properties

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

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

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

$\Delta Q = ml$

$pV = \frac{1}{3} N m\overline{c^2}$

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

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 $= eV$

$F = 6\pi\eta rv$

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

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

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

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

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

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

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

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

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

Astrophysics and Medical Physics

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

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

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

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

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

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

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

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

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

$v = Hd$

$P = \sigma A T^4$

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

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

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

Medical Physics

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

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

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

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

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

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

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

Alternating Currents

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

Operational amplifier

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

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

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

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