| Surname | | Other Names | |
|---|---|---|---|
| Centre Number | | Candidate Number | |
| Candidate Signature | | | |

Leave blank

General Certificate of Education
January 2001
Advanced Subsidiary Examination

ASSESSMENT and QUALIFICATIONS ALLIANCE

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

Thursday 18 January 2001 Morning Session

**In addition to this paper you will require:**
- a calculator;
- a protractor, a pencil and a ruler.

Time allowed: 1 hour 30 minutes

**Instructions**
- Use blue or black ink or ball-point pen.
- Fill in the boxes at the top of this page.
- Answer **all** questions in the spaces provided. All working must be shown.
- Do all rough work in this book. Cross through any work you do not want marked.
- A *Data Sheet* is provided on pages 3 and 4. Detach this perforated sheet at the start of the examination.

**Information**
- The maximum mark for this paper is 60.
- Mark allocations are shown in brackets.
- The paper carries 30% of the total marks for Physics Advanced Subsidiary and carries 15% of the total marks for Physics Advanced.
- You are expected to use a calculator where appropriate.
- In questions requiring description and explanation you will be assessed on your ability to use an appropriate form and style of writing, to organise relevant information clearly and coherently, and to use specialist vocabulary where appropriate. The degree of legibility of your handwriting and the level of accuracy of your spelling, punctuation and grammar will also be taken into account.

| For Examiner's Use | | | |
|---|---|---|---|
| Number | Mark | Number | Mark |
| 1 | | | |
| 2 | | | |
| 3 | | | |
| 4 | | | |
| 5 | | | |
| 6 | | | |
| | | | |
| | | | |
| | | | |
| | | | |
| | | | |
| | | | |
| Total (Column 1) → | | | |
| Total (Column 2) → | | | |
| TOTAL | | | |
| Examiner's Initials | | | |

**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.
- Detach this sheet before you begin work.

**The Data Sheet will replace this page**

**Turn over**

**The Data Sheet will replace this page**

**NO QUESTIONS APPEAR ON THIS PAGE**

LEAVE MARGIN BLANK

**1** (a) State the condition necessary for the equilibrium of three coplanar forces acting at a point.

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

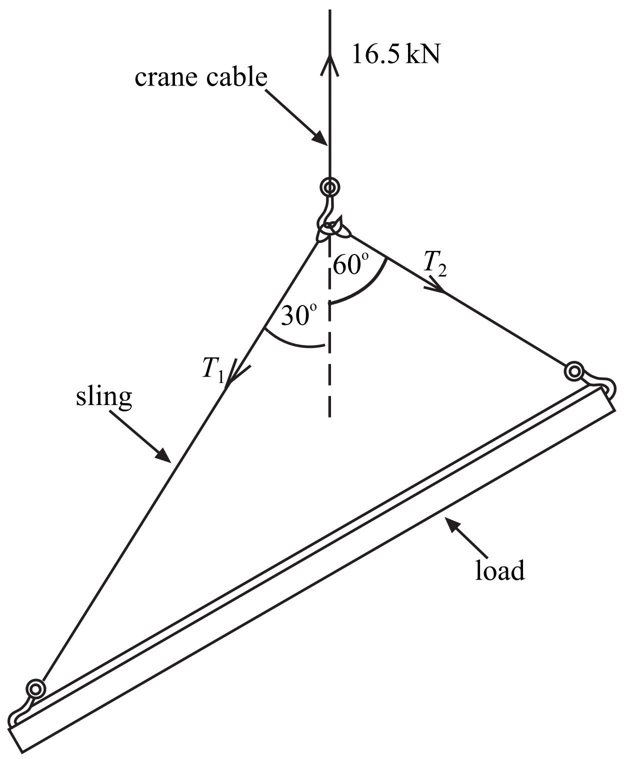
.....................................................................................................................................

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

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

*(1 mark)*

(b) The diagram shows a crane hook in equilibrium under the action of a vertical force of 16.5 kN in the crane cable and tension forces $T_1$ and $T_2$ in the sling.



LEAVE MARGIN BLANK

(b) (cont.)

Find the tension forces $T_1$ and $T_2$ acting in the sling. You may **either** calculate these forces **or** find them by scale drawing. In either case you should show your method clearly.

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

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

$T_1$ = ..................................

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

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

$T_2$ = ..................................

*(4 marks)*

5

**Turn over**

**2** (a) (i) Define the moment exerted by a force $F$ about a point P. You may draw a diagram if you wish.

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

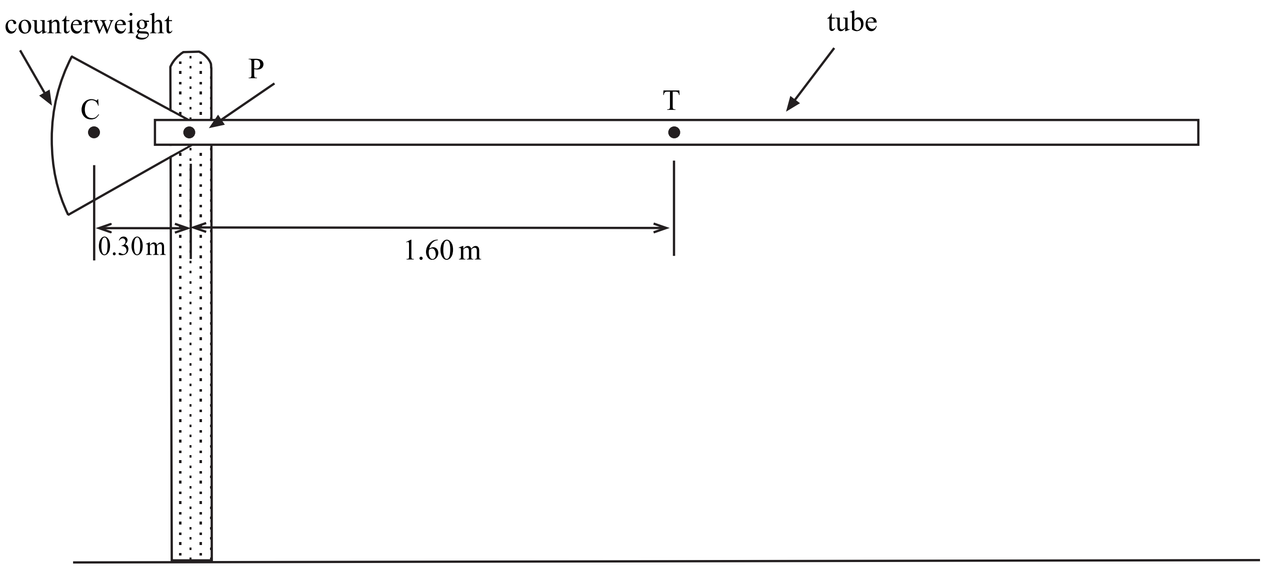
..........................................................................................................................................

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

(ii) State the unit of moment..........................................................

*(3 marks)*

(b) The long arm of the car-park barrier shown in the diagram is a tube of mass 12.0 kg which is free to rotate about a fixed pivot P near one end. A counterweight is attached firmly to one end of the tube so that the barrier is in equilibrium with its long arm horizontal. Points C and T on the diagram show the locations of the centre of mass of the counterweight and tube, respectively.



LEAVE MARGIN BLANK

(i) Draw on the diagram the lines of action and directions of all the forces acting on the tube and counterweight.

(ii) Calculate the weight of the tube.

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

(iii) Calculate the mass of the counterweight.

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

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

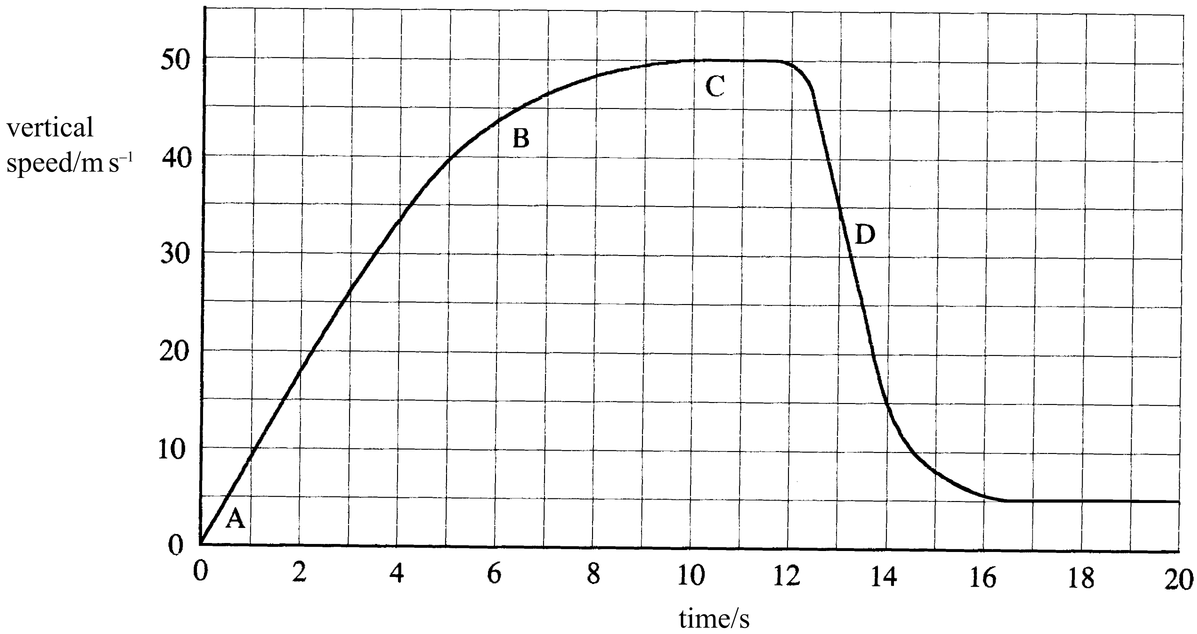
..............................................................................................................................

*(5 marks)*

— 8

**TURN OVER FOR THE NEXT QUESTION**

**3** The graph shows how the vertical speed of a parachutist changes with time during the first 20 s of his jump. To avoid air turbulence caused by the aircraft, he waits a short time after jumping before pulling the cord to release his parachute.




(a) Regions A, B and C of the graph show the speed before the parachute has opened. With reference to the forces acting on the parachutist, explain why the graph has this shape in the region marked

(i) A, ..........................................................................................................................

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

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

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

(ii) B, ..........................................................................................................................

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

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

(iii) C. ..........................................................................................................................

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

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

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

*(6 marks)*

LEAVE MARGIN BLANK

(b) Calculate the maximum deceleration of the parachutist in the region of the graph marked D, which shows how the speed changes just after the parachute has opened. Show your method clearly.

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

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

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

*(2 marks)*

(c) Use the graph to find the total vertical distance fallen by the parachutist in the first 10 s of the jump. Show your method clearly.

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

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

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

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

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

*(4 marks)*

(d) During his descent, the parachutist drifts sideways in the wind and hits the ground with a vertical speed of $5.0\,m\,s^{-1}$ and a horizontal speed of $3.0\,m\,s^{-1}$. Find

(i) the resultant speed with which he hits the ground,

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

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

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

(ii) the angle his resultant velocity makes with the vertical.

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

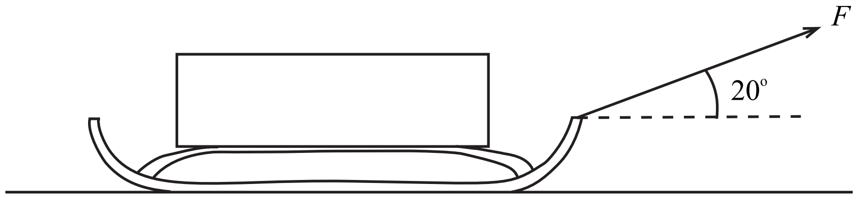
..........................................................................................................................

*(2 marks)*

*14*

**Turn over ▸**

**4** A heavy sledge is pulled across snowfields. The diagram shows the direction of the force *F* exerted on the sledge. Once the sledge is moving, the average horizontal force needed to keep it moving at a steady speed over level ground is 300 N.




(a) Calculate the force *F* needed to produce a horizontal component of 300 N on the sledge.

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

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

*(1 mark)*

(b) (i) Explain why the work done in pulling the sledge **cannot** be calculated by multiplying *F* by the distance the sledge is pulled.

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

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

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

(ii) Calculate the work done in pulling the sledge a distance of 8.0 km over level ground.

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

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

(iii) Calculate the average power used to pull the sledge 8.0 km in 5.0 hours.

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

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

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

*(6 marks)*

LEAVE MARGIN BLANK

(c) The same average power is maintained when pulling the sledge uphill. Explain **in terms of energy transformations** why it would take longer than 5.0 hours to cover 8.0 km uphill.

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

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

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

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

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

*(3 marks)*

10

**TURN OVER FOR THE NEXT QUESTION**

**Turn over**

LEAVE MARGIN BLANK

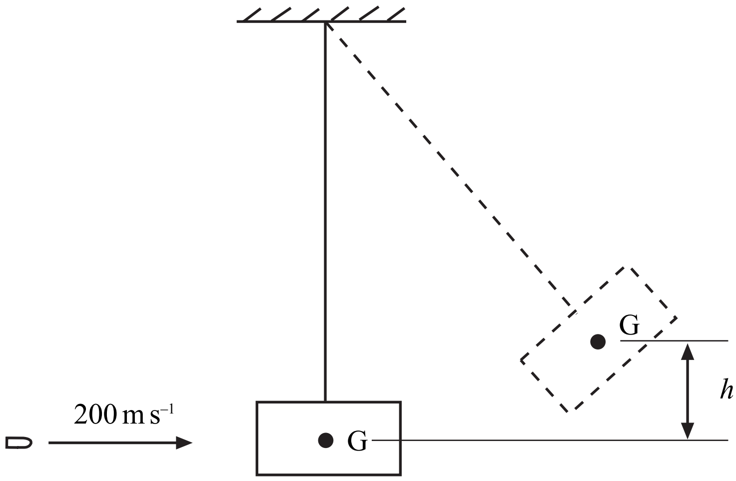
**5** (a) State the principle of conservation of linear momentum for two colliding bodies.

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

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

.......................................................................................................................................
*(2 marks)*

(b)




A bullet of mass 0.010 kg travelling at a speed of 200 m s$^{-1}$ strikes a block of wood of mass 0.390 kg hanging at rest from a long string. The bullet enters the block and lodges in the block. Calculate

(i) the linear momentum of the bullet before it strikes the block,

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

(ii) the speed with which the block first moves from rest after the bullet strikes it.

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

.......................................................................................................................................
*(4 marks)*

(c) During the collision of the bullet and block, kinetic energy is converted into internal energy which results in a temperature rise.

(i) Show that the kinetic energy of the bullet before it strikes the block is 200 J.

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

(ii) Show that the kinetic energy of the combined block and bullet immediately after the bullet has lodged in the block is 5.0 J.

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

(iii) The material from which the bullet is made has a specific heat capacity of $250\,\mathrm{J\,kg^{-1}\,K^{-1}}$. Assuming that all the lost kinetic energy becomes internal energy in the bullet, calculate its temperature rise during the collision.

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

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

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

*(5 marks)*

(d) The bullet lodges at the centre of mass G of the block. Calculate the vertical height *h* through which the block rises after the collision.

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

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

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

*(2 marks)*

*13*

**TURN OVER FOR THE NEXT QUESTION**

**6** (a) Write down **four** assumptions about the properties and behaviour of gas molecules which are used in the kinetic theory to derive an expression for the pressure of an ideal gas.

Assumption 1 ...................................................................................................................

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

Assumption 2 ...................................................................................................................

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

Assumption 3 ...................................................................................................................

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

Assumption 4 ...................................................................................................................

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

*(4 marks)*

(b) (i) A cylinder, fitted with a pressure gauge, contains an ideal gas and is stored in a cold room. When the cylinder is moved to a warmer room the pressure of the gas is seen to increase. Explain **in terms of the kinetic theory** why this increase in pressure is expected.

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

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

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

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

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

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

(ii) After a time, the pressure of the gas stops rising and remains steady at its new value. The air temperature in the warmer room is 27 °C. Calculate the mean kinetic energy of a gas molecule in the cylinder.

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

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

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

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

*(6 marks)*

*10*

**END OF QUESTIONS**