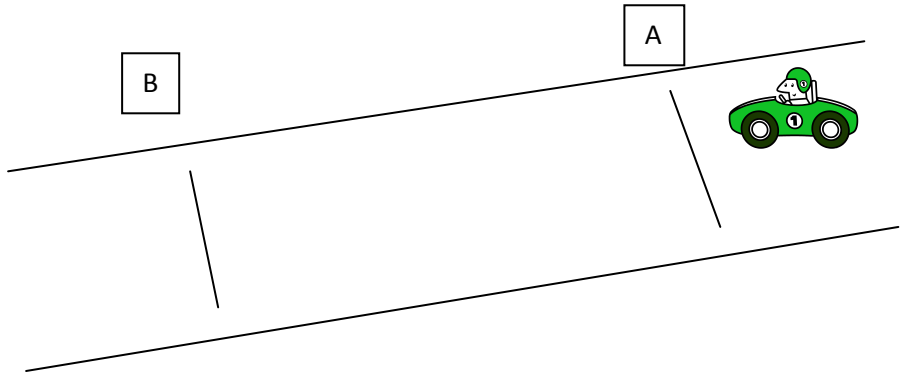
CfE Advanced Higher Physics

Rotational Motion & Astrophysics Past Paper Homework

1.Kinematic Relationships

1. The average acceleration of a radio controlled car is investigated by a student.

She marks distance AB on a straight track, as shown below and measures this distance using a measuring tape.



She places the car at A and uses the radio control to accelerate the car.
The car starts from rest and accelerates in a straight line along the track to B.
Using a stopwatch, the student measures the time for the car to travel the distance AB.

She repeats this several times and obtains the following results.
Distance AB = (3.54+/- 0.01)m.

Stopwatch readings: 2.53s, 2.29s, 2.34s, 2.36s, 2.65s, 2.53s.

(i) Starting with the appropriate equation of motion, show that the acceleration of the car is given by

$a = \frac{2s}{t^2}$ where the symbols have their usual meanings. 3

(ii) Calculate the average value of the car's acceleration. 2

(iii) Calculate the random uncertainty in the time measurement. 3

(iv) Calculate the percentage uncertainty in the average acceleration. 4

(v) Express the numberical result of her investigation in the form. 2

final value +/- absolute uncertainty. **(14)**

2. (*a*) A particle has displacement $s = 0$ at time $t = 0$ and moves with constant acceleration a.

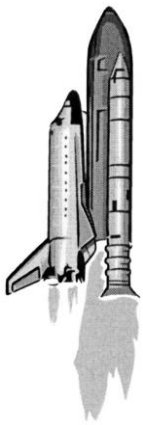
The velocity of the object is given by the equation $v = u + at$, where the symbols have their usual meanings.

Using calculus, derive an equation for the displacement s of the object as a function of time t. **4**

(*b*) A cyclotron accelerates protons to a velocity of 2.80×10^8 ms^{-1}
Calculate the relativistic energy of a proton at this velocity. **7**

(11)

3 . Figure 1A shows a space shuttle shortly after take-off.



(a) Immediately after take off, the vertical displacement of the shuttle for part of its journey can be described using the equation

$$s = 3.1t^2 + 4.1t.$$

(i) Find, by differentiation, the equation for the vertical velocity of the shuttle. 2

(ii) At what time will the vertical velocity be $72ms^{-1}$? 3

(iii) Calculate the vertical linear acceleration during this time. 2

(7)

4. A particle accelerator produces protons with a relativistic mass of 4.66×10^{-27} kg. Calculate the speed of these protons. **3**

5. The relativistic mass *m* of a moving object is given by

$$m = \frac{m_o}{\sqrt{1 - \frac{v^2}{c^2}}}$$

where the symbols have their usual meanings.

a) Calculate the speed at which the relativistic mass of an object is equal to three times its rest mass. 3

b) An electron is emitted with a speed of 0.90c from a radioactive nucleus. Calculate the relativistic energy of this electron. 5

(8)

Total Marks 43