

Dimensional Analysis – 2022 GCE Mechanics Further Math A Y543**1. June/2022/Paper_Y543/01/No.4**

When two objects are placed a distance apart in outer space each applies a gravitational force to the other. It is suggested that the magnitude of this force depends on the masses of both objects and the distance between them. Assuming that this suggestion is correct, it is further assumed that the magnitude of this force is given by a relationship of the form

$$F = Gm_1^\alpha m_2^\beta r^\gamma$$

where

- F is the magnitude of the force
- m_1 and m_2 are the masses of the two objects
- r is the distance between the two objects
- G is a constant.

(a) Using a dimensional argument based on Newton's third law explain why $\alpha = \beta$. [1]

It is given that the magnitude of the gravitational force is given by such a relationship and that $G = 6.67 \times 10^{-11} \text{ m}^3 \text{ kg}^{-1} \text{ s}^{-2}$.

(b) Write down the dimensions of G . [1]

(c) By using dimensional analysis, determine the values of α , β and γ . [3]

You are given that the mass of the Earth is $5.97 \times 10^{24} \text{ kg}$ and that the distance of the Moon from the Earth is $3.84 \times 10^8 \text{ m}$. You may assume that the only force acting on the Moon is the gravitational force due to the Earth.

(d) By modelling the Earth as stationary and assuming that the Moon moves in a circular orbit around the Earth, determine the period of the motion of the Moon. Give your answer to the nearest day. [3]