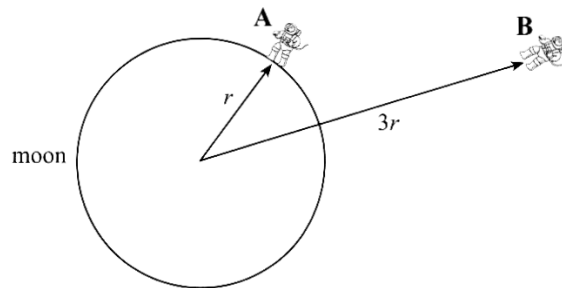


Gravitation and Satellites Assignment

1. The Firefly class space vessel Serenity with some cargo on board has a mass of approximately $3.5 \times 10^5 \text{ kg}$. Out of fuel, it drifts towards the desert planet Rigel II, $4.1 \times 10^3 \text{ km}$ away.
- Calculate the force Serenity experiences, if according to the on-board database Rigel II has a mass of $8.9 \times 10^{23} \text{ kg}$. /3
 - State the force Rigel II feels due to the presence of Serenity. /1
 - Calculate the acceleration of Serenity due to Rigel II's gravity. /3
 - State and explain the effect on the acceleration of Serenity if her passengers were to throw off some of their cargo. /2
2. State two differences between geostationary orbits and polar orbits. /2
- 3.
- Using the relationships $v = \sqrt{\frac{GM}{r}}$ and $v = \frac{2\pi r}{T}$, show that the radius of a satellite orbiting the Earth can be given by the equation $r = \sqrt[3]{\frac{GMT^2}{4\pi^2}}$, where M is the mass of the Earth, T is the period of the satellite, and r is the radius of the orbit. /2
 - Hence determine the *altitude* of a satellite in a geostationary orbit around the Earth. The mass of the Earth is $M = 5.97 \times 10^{24} \text{ kg}$ and its radius is $R = 6.4 \times 10^6 \text{ m}$. /3
4. Astronaut **A** is on the surface of a moon of radius r . Astronaut **B** is at a distance of $3r$ from the centre of the moon, as shown in the diagram below:



Astronaut **A** and astronaut **B** have identical masses. The magnitude of the gravitational force between the moon and astronaut **A** is 195 N .

Calculate, *using proportionality*, the magnitude of the gravitational force between the moon and astronaut **B**.

/3

TOTAL /19

Optional revision questions

- 1.
- The time of flight of some projectile was measured to be 18.7 s , and its range was $1.98 \times 10^3 \text{ m}$. Show that the launch angle θ that resulted in this range was approximately 41° , given that the launch speed was 140 ms^{-1} .
 - State the other launch angle that would result in the same range.
 - State and explain the effect of this different launch angle on the time of flight of the projectile.
2. A car is driving around a banked curve at the optimum speed.
- Use a diagram to show the forces acting on the car and hence explain the effect on the car's motion if the surface of the road were to become icy.
 - In terms of components of force, discuss how your answer to part a would change if the curve were banked
 - less steeply
 - more steeply