Gravitation and Satellites Questions

1. The Firefly class space vessel Serenity with some cargo on board has a mass of approximately 3.5×10^5kg. Out of fuel, it drifts towards the desert planet Rigel II, 4.1×10^5km away.

a) Calculate the force Serenity experiences, if according to the on-board database Rigel II has a mass of 8.9×10^{23}kg. /3

b) State the force Rigel II feels due to the presence of Serenity. /1

c) Calculate the acceleration of Serenity due to Rigel II's gravity. /3

d) State and explain the effect on the acceleration of Serenity if her passengers were to throw off some of their cargo. /2

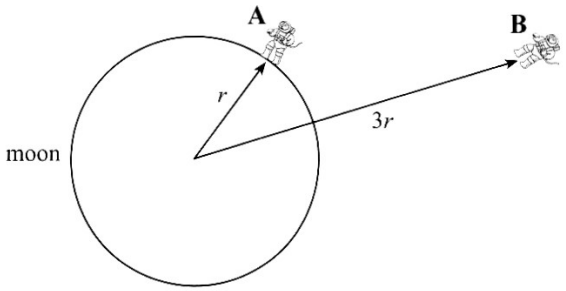
2. State two differences between geostationary orbits and polar orbits. /2

3.

a) 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

b) Hence determine the *altitude* of a satellite in a geostationary orbit around the Earth. The mass of the Earth is $M = 5.97\times10^{24}$kg and its radius is $R = 6.4\times10^6$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.

a) The time of flight of some projectile was measured to be 18.7s, and its range was 1.98×10^3m. Show that the launch angle θ that resulted in this range was approximately 41°, given that the launch speed was 140ms^{-1}.

b) State the other launch angle that would result in the same range.

c) 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.

(a) 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.

(b) In terms of components of force, discuss how your answer to part a would change if the curve were banked

(i) less steeply

(ii) more steeply