Universal Law of Gravity A22

Please find all required values and constants at the back of this sheet.

1. Complete the following sentences:

a) The smaller the distance between two objects is, the ..... the gravitational force between them is.

b) The smaller the masses of two objects are, the ..... the gravitational force between them is.

2. Given are two objects of mass m_1 and m_2, whose centers are located at the distance r. Complete the following sentences:

a) If m_1 is tripled, without changin m_2 and r, the gravitational force changes by the factor .....

b) If m_1 and m_2 are halved, without changing r, the gravitational force changes by the factor .....

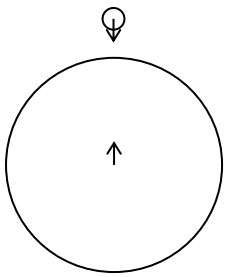
c) If r is tripled, without changing m_1 and m_2, the gravitational force changes by the factor .....

d) If r is divided by four, without changing m_1 and m_2, the gravitational force changes by the factor .....

3. Two identical objects attract each other gravitationally with a force of 2.5 µN when they are 1.25 cm apart.
Calculate their individual masses.

4. The mass of a planet or the moon can be calculated from the acceleration of gravity at its surface and its radius.
The force of gravity $F_G = m_{object} \cdot g$ is the attractive force between the moon and the object:

$$F_G = m_{object} \cdot g = G \cdot \frac{m_{object} \cdot m_{moon}}{r^2_{moon}}$$



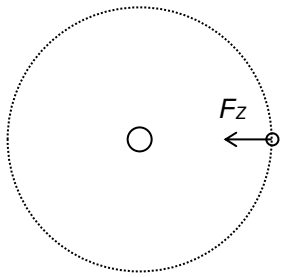
Solve the above equation for m_{moon}. Calculate the moon's mass from the gravitational constant G, the moon's radius r_{moon} and the acceleration of free fall g on the moon.

5. Calculate the acceleration of gravity g at mercury's surface from its radius and mass.

6. Calculate the acceleration of free fall g
a) at 6.4 km above the earth's surface
b) at 6400 km above the earth's surface

7. If you doubled the mass and tripled the radius of a planet, by what factor would g at its surface change?

8. The sun's mass can be calculated from the distance between the sun and a planet and the planet's orbital period:
The gravitational force acts as centripetal force $F_Z = m \cdot a_Z$, which holds the planet in the sun's orbit:



$$F_Z = m_{planet} \cdot a_Z = m_{planet} \cdot \omega^2 \cdot r_{planet\text{-}sun} = G \cdot \frac{m_{planet} \cdot m_{sun}}{r^2_{planet\text{-}sun}}$$

Solve the above equation for the mass of the sun and calculate the sun's mass from Mercury's orbital period and distance from the sun.

9. A geosynchroneous satellite is one that stays above the same point on the Earth.
a) Why is this possible only if the satellite stays at a point above the equator?
b) What is the orbital period of such a satellite?
c) What is the height above the Earth's surface at which such a satellite must orbit?

Table:

gravitational constant	$G = 6.67 \cdot 10^{-11} \ \frac{N \cdot m^2}{kg^2}$
acceleration of gravity on the moon	$g = 1.62 \ \frac{m}{s^2}$
Moon's radius	r_{moon} = 1'737 km
Mercury's mass	$m_{mercury} = 3.29 \cdot 10^{23}$ kg
Mercury's radius	$r_{mercury}$ = 2'440 km
Mercury's distance from the sun	$r_{mercury\text{-}sun} = 5.79 \cdot 10^{10}$ m
Mercury's orbital period	$T_{mercury}$ = 87.97 d
Earth's radius	r_{earth} = 6'371 km
Earth's mass	$m_{earth} = 5.97 \cdot 10^{24}$ kg

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solutions:
3. 2.42 kg
4. $7.32 \cdot 10^{22}$ kg
5. 3.7 $\frac{m}{s^2}$
6. a) 9.8 $\frac{m}{s^2}$ b) 2.4 $\frac{m}{s^2}$
7. 0.22
8. $1.99 \cdot 10^{30}$ kg
9. b) 24 h c) 36'000 km