Name: _____ Section: ____

Tuesday, September 8

Quiz 2A

Your starship lands on mysterious planet Y. As chief scientist-engineer, you measure the acceleration of gravity on the surface of the planet and find it to be 1.0 m/s^2. The radius of the planet is 3.2×10^7 m. There is no appreciable atmosphere.

a. What is the mass of the planet, in kg?

$$g = G\frac{M}{R^2}$$

$$M = \frac{gR^2}{G} = \frac{\left(1.0\ \frac{m}{s^2}\right)\left(3.2\times10^7\ m\right)^2}{6.67\times10^{-11}\ \frac{Nm^2}{kg^2}} = 1.54\times10^{25}\ kg$$

b. If the starship goes into a circular orbit 5,000 km above the surface of the planet, how many hours will it take the ship to complete one orbit?

$$T = \frac{2\pi r^{3/2}}{\sqrt{GM}}$$

$$= \frac{2\pi\left(3.2\times10^7\ m + 5\times10^6\ m\right)^{3/2}}{\sqrt{\left(6.67\times10^{-11}\ \frac{Nm^2}{kg^2}\right)\left(1.54\times10^{25}\ kg\right)}} = 44191\ s$$

$$= 12\ h$$

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Quiz 2B

Your starship lands on mysterious planet Z. The radius of the planet is 3.2×10^6 m; and there is no appreciable atmosphere. A small moon moves on a circular orbit with period 42 hours. The distance between the moon and the center of planet Z is 8.0×10^7 m

a. What is the mass of the planet, in kg?

$$T = \frac{2\pi a^{3/2}}{\sqrt{GM}} \quad \Rightarrow \quad M = \frac{4\pi^2 a^3}{GT^2}$$

$$M = \frac{4\pi^2 (8.0\times10^7\ m)^3}{\left(6.67\times10^{-11}\ \frac{Nm^2}{kg^2}\right)\left(42h \cdot \frac{3600s}{1h}\right)^2} = \boxed{1.33\times10^{25}\ kg}$$

b. What is the magnitude of the acceleration of gravity on the surface of the planet?

$$g = \frac{GM}{R^2} = \frac{\left(6.67\times10^{-11}\ \frac{Nm^2}{kg^2}\right)(1.33\times10^{25}\ kg)}{(3.2\times10^6\ m)^2}$$

$$= \boxed{86\ m/s^2}$$

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Quiz 2C

In a galaxy far, far away, Darth Vader has set the Death Star in a circular orbit 9.0×10^7 m above the surface of planet Endor, whose circumference at the equator is 2.0×10^8 m. The period of the orbit is 27 hours.

a. What is the mass of Endor?

$$R_{Endor} = \frac{2.0 \times 10^8 m}{2\pi} = 3.18 \times 10^7 m$$

$$T = \frac{2\pi a^{3/2}}{\sqrt{GM}} \rightarrow M = \frac{4\pi^2 a^3}{GT^2}$$

$$M = \frac{4\pi^2 \left(3.18 \times 10^7 m + 9.0 \times 10^7 m\right)^3}{\left(6.67 \times 10^{-11} \frac{Nm^2}{kg^2}\right)\left(27h \cdot \frac{3600s}{1h}\right)^2} = \boxed{1.13 \times 10^{26} kg}$$

b. What is the magnitude of the gravitational acceleration on the surface of Endor?

$$g = \frac{GM}{R^2}$$

$$= \frac{\left(6.67 \times 10^{-11} \frac{Nm^2}{kg^2}\right)\left(1.13 \times 10^{26} kg\right)}{\left(3.18 \times 10^7 m\right)^2}$$

$$= \boxed{7.5 \ m/s^2}$$

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Quiz 2D

In a galaxy far, far away, Darth Vader sets his starfighter in a circular orbit 34,000 km above the surface of Tatooine. The magnitude of the gravitational acceleration g on the surface of Tatooine is identical to that on Earth, although Tatooine's mass is 1.0×10^{25} kg –a little larger than Earth's.

a. What is the radius of Tatooine?

$$g = \frac{GM}{R^2}$$

$$R = \sqrt{\frac{GM}{g}} = \sqrt{\frac{\left(6.67\times10^{-11}\ \frac{Nm^2}{kg^2}\right)(1.0\times10^{25}\ kg)}{9.81\ m/s^2}}$$

$$= \boxed{8.25\times10^{6}\ m}$$

b. What is the period of Darth Vader's starfighter?

$$T = \frac{2\pi a^{3/2}}{\sqrt{GM}}$$

$$= \frac{2\pi\left(8.2\times10^{6}\ m + 34\times10^{6}\ m\right)^{3/2}}{\sqrt{\left(6.67\times10^{-11}\ \frac{Nm^2}{kg^2}\right)(1.0\times10^{25}\ kg)}}$$

$$= 66800\ s \cdot \frac{1h}{3600\ s} = \boxed{19\ h}$$