Gravity ... gets me down! ... Questions 2 A Physics

B. .... Satellites

2 The preliminary stage of the Apollo 11's journey to the moon was to put it in a parking orbit 189 km above the Earth's surface. Calculate...

(a) gravitational intensity (field strength, to you + me) at this height (2

(b) speed of the spacecraft (2)

(c) time for 1 orbit. (2)

An astronaut sees the Earth below and sheds a tear of wonder. Explain why the drop of water....

(d) "hangs" motionless in the spacecraft. (Is there no gravity, or...?) (

(e) is spherical ("surface tension") (2), and...(f) is slightly salty (2)

3 (a) At what speed must a satellite travel so it remains in a circular orbit 1.6×10^3 km above the Earth's surface? (3)

(b) What is the satellite's orbit time? (2)

(c) What is the gravity field strength at this height? (2)

4. Use the data on sheet 1 to calculate...

(a) the Earth and Moon's gravitational force on each other (2)

(b) The time period of the moon's orbit. (2)

5. A satellite is in geostationary orbit around a planet of mass 1.2×10^{25} kg, radius 8×10^6 m, day length 16 hours, and an atmosphere similar to Earth's.

(a). Draw a labelled diagram to show where the orbit <u>must</u> be. (2)

(b) What is the orbit time period + radius.? (3)

(c) What is the gravitational potential of the satellite at this orbit? (2)

(d) What is the maximum velocity the satellite could have if it fell to the planet's surface? Why will it not reach this velocity? (3)

(H) 6. By considering the Moon's gravitational field strength at the Earth's core, and on the seas on the near side, explain the Moon's rôle in causing tides.

☆ 1. Show that, for any satellite in a circular orbit, its velocity $v = \sqrt{\frac{GM}{r}}$ where M is planet mass, r is orbit radius (2)

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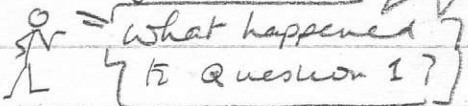
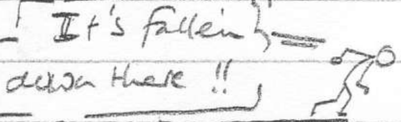
Gravity – ~~1~~ 2 !! Answers   A Physics





B

1.

2\. (a) $g = GM_E/r^2$ (1) — force on 1 kg = 9.26 (1) N/kg

if height = 189 km; $r = 6.59 \times 10^6$ m

(b) $F_g = m_s g = F_c = m_s v^2/r$ (1) $\rightarrow v = \sqrt{gr} = 7810$ (1) m/s (3 s.f.)

(c) D orbit $= 2\pi r = vT_{period}$ (1) $\rightarrow T = 2\pi r/v = 5{,}300$ s (1) = 1.5 hr approx

(d)

g_{local} Both teardrop + spacecraft are falling to Earth at the same rate – just enough to follow a circular path – so both fall together /2

(e)

attraction forces between molecules pull drop into smallest volume (2)

(f) tears, come from blood plasma are slightly salty to keep body cells swollen by osmosis (2) $\boxed{12}$

3 (a) $F_g = G M_E m_s/r^2 = F_c = m_s v^2/r$ (1) $\rightarrow v = \sqrt{GM_E/r}$ (1) $= 7090$ (1) m/s /3

(b) D orbit $= 2\pi r_{orbit} = vT$ (1) $\rightarrow T = 2\pi r/v = 7092$ (1) s (= 1.97 hours) /2

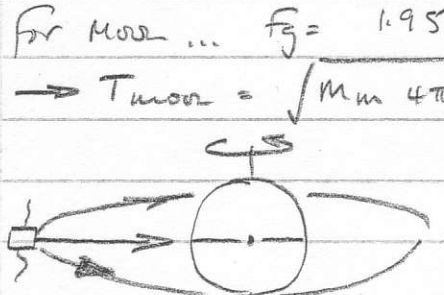
(c) g at orbit $= GM_E/r^2$ (1) $= 6.28$ (1) N/kg /2 $\boxed{7}$

4\. (a) Grav. attraction between Earth + Moon $= G M_E m_m/r^2$ (1) $= 1.95 \times 10^{20}$ N (1) /2

(b) For Moon ... $F_g = 1.95 \times 10^{20}$ (N) $= m_m \omega^2 r$ (1) $= m_m \frac{4\pi^2}{T^2} r_{moon's\ orbit}$

$\rightarrow T_{moon} = \sqrt{m_m 4\pi^2 r / 1.95 \times 10^{20}} = 2.32 \times 10^6$ s (1) (27 days) /2

5 (a)



The geostationary orbit must.... (1) be centred on the planet's centre (1) (2) be in the same plane as the equator (1) (3) be in the same direction as the planet's rotation

(b) $G M_p \cancel{m_s}/r_s^2 = m_s \omega^2 r_s = \cancel{m_s} \frac{4\pi^2}{T^2} r_s \rightarrow r_s^3 = G M_p \frac{T^2}{4\pi^2}$ (1)

$T = 16$ h $= 1{,}382{,}400$ s (1) $r_s = \sqrt[3]{3.89 \times 10^{25}} \rightarrow r_s = 3.39 \times 10^8$ m (1) /3

(c) at this height $V_g = -GM/r$ (1) J/kg $= 2.37 \times 10^6$ (1) J/kg of satellite /2

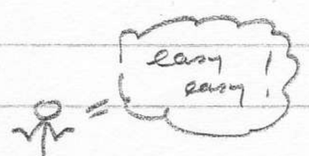
(d) So satellite's grav. potential $= m_s V_g$ (m_s unknown)

If satellite falls to planet $\cancel{m_s} V_g = \frac{1}{2} \cancel{m_s} v^2$ (1) $\rightarrow v = \sqrt{2V_g} = 2178$ (1) m/s

will not reach this velocity because of friction with planet's atmosphere

Grav. potential $\rightarrow$ KE / Heat energy (1) /3

1\. For any satellite $F_g = \frac{GMm}{r^2} = F_c = \frac{mv^2}{r}$ so $v^2 = \frac{GM}{r}$; $v = \sqrt{\frac{GM}{r}}$ /2



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