Topic Test – Gravity

A – Physics

1. Write the formula for gravitational attraction – name all symbols + units (3)

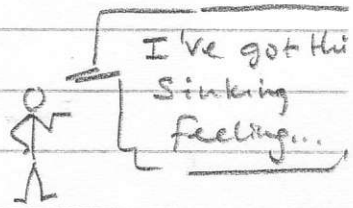
2. Define ....
   (a) gravity field strength, in words, and with the formula + unit, (3)
   (b) gravitational potential, in words and with the formula + unit (3)
   (c) Why is distance measured from the centre of a planet? (1) [1]

3. This question is about gravity and the Moon.
   (a) Use the data to calculate the volume of the Moon (2)
   (b) Calculate the mass of the Moon (2)
   (c) Find the gravity field strength at the Moon's surface (2)
   (d) Find the value of gravitational potential at the Moon's surface (2)

   Sketch graphs to show how ...
   (e) field strength varies with distance from the Moon's centre (4)
   (f) gravitational potential varies with distance (4)
   (g) What does the phrase "escape velocity" mean? (2)
   (h) What is the escape velocity for the Moon? (2) [20]

4. This question is about a geostationary satellite.
   (a) What must be its time period...? (1)
   (b) What does "geostationary" mean? (1)
   (c) What is the satellite's angular velocity? (2)
   (d) Calculate the satellite's altitude (3)
   (e) Above what part of the Earth must the satellite be, and why? (2)

Data ...
- Volume of a sphere $V = \frac{4}{3}\pi r^3$
- Universal constant of Gravitation, $G = 6.7 \times 10^{-11}$ N m^2 kg^{-2}
- Moon's radius $R_M = 1.7 \times 10^6$ m
- Moon's average density $\rho_M = 3.4 \times 10^3$ kg m^{-3}
- Earth radius, $R_E = 6.4 \times 10^6$ m
- Earth's mass $M_E = 6 \times 10^{24}$ kg



TLN
7.98

[9]

Test – GRAVITY – Answers — A Physicist

1. $F_g = G M_1 M_2 / r^2$ — F force, N; G Universal constant, $N m^2 kg^{-2}$; masses, kg; distance, m — formula ① — all symbols ① — all units ① [3]

2. (a) $g = G M / r^2$ ① — g is force on a unit mass; grav. field strength, N/kg ①

(b) $V_g = -G M / r$ ① — V_g is work done in bringing a unit mass (1 kg) from infinity to that point in the field (always −) ①

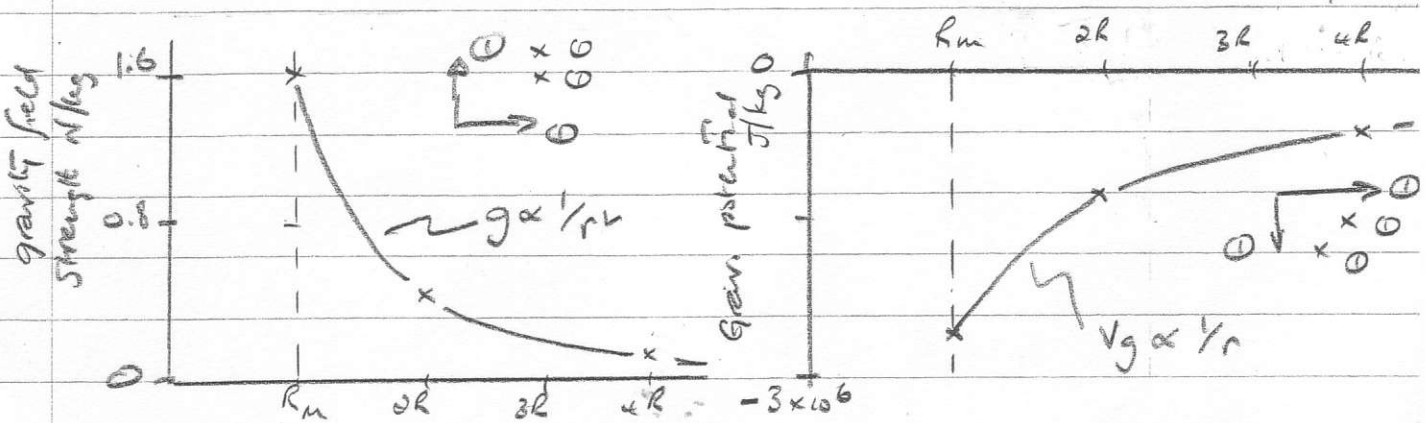
(c) because mass behaves as if concentrated at the centre ① [1]

3. (a) $V_{sphere} = 4/3 \pi r^3 = 2.1 \times 10^{19}$ ① m^3 ①

(b) mass $m = \rho V$ (or DV) $= 7.0 \times 10^{22}$ ① kg ①

(c) $g = G M_{moon} / R_m^2$ ① $= 1.62$ ① N/kg

(d) V_g at Moon's surface $= -G M_{moon} / R_m$ ① $= -2.76 \times 10^6$ ① J/kg



(g) escape velocity – the minimum velocity ① needed to escape from ① the planet's gravity field (assuming 0 air resistance.)

(h) $\frac{1}{2} m v_{esc}^2 = KE = V_g$ ① $= 2.76 \times 10^6$ J/kg — set mass to 1 kg.

so $v_{esc} = 2350$ m/s ①

4 (a) T.P. = 24 hr ① (23 h 56 m if you're picky.)

(b) orbit to stay above same part of Earth = ①

same T.P. ; or same angular velocity = hmm ... ok

"same speed as Earth" = meaningless.

(c) ang velocity $\omega = 2\pi / T$ ① $= 7.27 \times 10^{-5}$ ① rad/sec

(d) $F_g = F_{centripetal}$ so $G M_E m_S / R^2 = m_S \omega^2 R$ ① $\Rightarrow R^3 = G M_E / \omega^2$.

so radius $R = 42.4 \times 10^6$ m ① → altitude $= 36 \times 10^6$ ① m above Earth

(e) above equator ① ... so centre of orbit is also centre of Earth ①

[9]

Q... 1 / 3 — 2 / 7 — 3 / 20 — 4 / 9 — Total / 59