Gravitation Equations Worksheet

Level: A-Level / AP Physics 1 & 2 | Difficulty: Advanced | Topic: Mechanics

Practice gravitation with 10 problems on Newton's universal law, field strength, and orbital motion. Includes full worked solutions.

Equations you will need

F = Gm_1m_2/r^2	Newton's law of universal gravitation
g = GM/r^2	Gravitational field strength
v = ?(GM/r)	Orbital speed for circular orbit
T^2 = (4pi^2/GM)r^3	Kepler's 3rd law
U = -Gm_1m_2/r	Gravitational potential energy

Symbol key

Symbol	Quantity	Unit
F	force	N
G	gravitational constant	6.67 x 10?¹¹ N*m^2/kg^2
m	mass	kg
M	central body mass	kg
r	separation / orbit radius	m
g	field strength	N/kg or m/s^2
v	orbital speed	m/s
T	orbital period	s

Practice problems

1. Find gravitational force between two 100 kg masses 2 m apart.

2. Find g at Earth's surface. (M=5.97x10^24 kg, r=6.37x106 m)

3. Find orbital speed at 7x106 m above Earth's centre.

4. Find period of a satellite orbiting Earth at radius 8x106 m.

5. Find gravitational PE of a 1000 kg satellite at 4x107 m from Earth's centre.

6. Find g at 2x107 m above Earth's centre (about 3 Earth radii).

7. At what height above Earth's surface is g half its surface value?

8. Find the mass of the Sun given Earth's orbital radius ($1.5x10^{11}$ m) and period (3.16x107 s).

9. Find the escape velocity from Earth's surface.

10. A geostationary satellite has T = 86,400 s. Find its orbital radius.

Answer key

Full worked solutions for each problem.

1. F = (6.67x10?¹¹)(104)/4 = 1.67x10?7 N
2. g = (6.67x10?¹¹)(5.97x10^24)/(6.37x106)^2 = 9.81 m/s^2
3. v = ?((6.67x10?¹¹)(5.97x10^24)/7x106) = 7546 m/s
4. v = ?(GM/r) = 7058 m/s; T = 2pir/v = 7123 s ? 119 min
5. U = -(6.67x10?¹¹)(5.97x10^24)(1000)/4x107 = -9.95x109 J
6. g = GM/r^2 = (3.98x10¹4)/4x10¹4 = 0.995 m/s^2
7. r_2^2 = 2r_1^2 -> r_2 = r_1?2 = 9.01x106 m; h = r_2 - 6.37x106 = 2.64x106 m
8. M = (4pi^2r^3)/(GT^2) = 2.0x10^30 kg
9. v_esc = ?(2GM/r) = ?(2 x 3.98x10¹4/6.37x106) = 11,200 m/s
10. r^3 = GMT^2/(4pi^2) = 7.54x10^2^2 -> r = 4.23x107 m