

1 Some basic math

1) Circumference of a circle

$$C = 2\pi r \quad (1)$$

where r is the radius of the circle.

2) Relationship between angular size, θ and linear size, x , of an object

$$\frac{\theta}{360} = \frac{x}{2\pi r} \quad (2)$$

where r is the distance to the object.

3) SOHCAHTOA trig relationships

$$\sin\theta = \frac{O}{H} \quad (3)$$

$$\cos\theta = \frac{A}{H} \quad (4)$$

$$\tan\theta = \frac{O}{A} \quad (5)$$

2 Velocity and acceleration

$$v = \frac{d}{t} \quad (6)$$

where v = velocity, d = distance and t = time.

$$a = \frac{v_f - v_i}{t} \quad (7)$$

where a = acceleration, v_i is the initial velocity, v_f is the final velocity and t is the time taken to go between them. **Make sure all units match!**

3 Kepler's laws of planetary motion

Kepler's 3rd Law

$$P^2 = a^3 \tag{8}$$

where P is the period in years and a is the orbital radius in AU.

4 Newton's laws of motion

Newton's 2nd Law

$$F = ma \tag{9}$$

where F is the force in Newtons (N), m is the mass in kg, and a is the acceleration in m/s^2 .

5 Newton's Universal Law of Gravity

The force of gravity between two objects is given by

$$F_g = \frac{GMm}{r^2} \tag{10}$$

where F_g is the force of gravity in N, M and m are the masses of the two objects in kg, and r is the distance between them in m.

6 Surface gravity

Remember, surface gravity is an acceleration, *not* a force! It is the acceleration you feel due to the gravity of a nearby object.

$$g = \frac{GM}{r^2} \tag{11}$$

where g is the surface gravity in m/s^2 , G is the gravitational constant, M is the mass of the object providing the force of gravity (e.g. Earth), and r is the radius of the object.

7 Centripetal Force

Centripetal force is the force that keeps an object in circular motion. It can be expressed as

$$F_c = \frac{mv^2}{r} \quad (12)$$

where F_c is the centripetal force in N, m is the mass of the object in kg, v is the objects orbital velocity in m/s and r is the radius of the circle the object is moving in, in m.

8 Orbital Velocity

We came across two expressions for orbital velocity. If the mass of the object *being* orbited is known, we can use

$$v_{orb} = \sqrt{\frac{GM}{r}} \quad (13)$$

where v_{orb} is the orbital velocity in m/s, G is the gravitational constant, M is the mass of the object being orbited in kg, and r is the radius of the orbit in m.

If we know the period of the orbit but not the mass, we can instead use

$$v_{orb} = \frac{2\pi r}{P} \quad (14)$$

where r is the radius of the orbit and P is the period of the orbit. **Again, make sure the units all match here!**

9 Newton's generalization of Kepler's 3rd law

Newton generalized Kepler's 3rd law so it can be applied to any system of bodies in orbit of each other.

$$P^2 = \frac{4\pi^2}{GM} a^3 \quad (15)$$

where P is the orbital period, G is the gravitational constant, M is the mass of the object being orbited, and a is the orbital radius. To plug numbers in here, make sure you use standard units and that everything matches.

10 Escape velocity

$$v_{esc} = \sqrt{\frac{2GM}{r}} \quad (16)$$

Make sure you remember the factor of 2 here!

11 Kinetic energy

$$E_k = \frac{mv^2}{2} \quad (17)$$

where E_k is the kinetic energy in Joules (J), m is the mass of the object in kg, and v is the velocity of the object in m/s.

12 Angular momentum

The angular momentum of an object experiencing circular motion is given by

$$L = mvr \quad (18)$$

where L is the angular momentum, m is the mass of the object, v its velocity and r the radius of the circle it is moving in.

Good luck everyone!