Formulae

$$G\frac{M*m}{r^2} = \frac{mv^2}{r} \qquad a = \frac{4\pi^2 r}{T^2}$$

$$\frac{r^3}{t^2} = G\frac{M_{sun}}{4\pi^2} \qquad \frac{1}{2}mv^2 = G\frac{M_{sun}m}{2r}$$

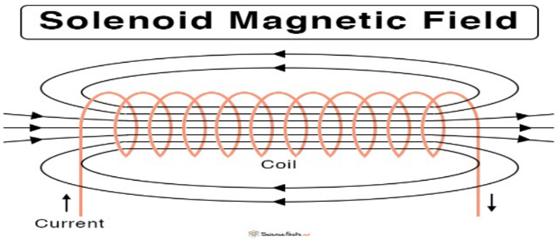
$$t = \sqrt{\frac{4\pi^2 r^3}{GM_{sun}}} \qquad v = \sqrt{G\frac{M_{sun}}{r}} = \frac{2\pi r}{t}$$

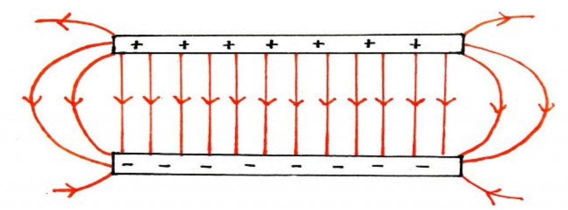
$$\tau = r_{\perp}F$$

$$E = vB$$

$$r = \sqrt[3]{\frac{GM_{sun}t^2}{4\pi^2}}$$

$$\frac{{r_1}^3}{{t_1}^2} = \frac{{r_2}^3}{{t_2}^2}$$





Theory

Field lines go from N to S, + to -. (For gravity, the mass always attracts)

Density of the field lines indicates strength (closer = stronger).

Field lines CANNOT touch.

Use the right-hand grip rule to determine the direction of the magnetic field. Use the right-hand slap rule to determine the force acting on the conductor.

All forces are vectors, and calculations should account for this.

In a stable circular orbit, momentum changes but kinetic energy remains constant.

If mass is halved, the work will also be halved because $w = fd$ and force is proportional to the mass.

For a satellite to be geostationary, it must; have a period of 24 hours, orbit directly above the equator, and orbit same direction as earth's rotation (W to E).

In line with Kepler's Third Law (insert law), a satellite's period is unaffected by changes in its own mass because the period depends only on the mass of the central celestial body it orbits and the distance from that body's centre of mass.

The inverse square law states that the intensity a physical quantity radiating from a point source (like gravity) decreases proportionally to the inverse of the square of the distance from that source ($g \propto \frac{1}{r^2}$)

Gravitational field strength is $0\ Nkg^{-1}$ at the centre of Earth due to appeal to symmetry as the vector sum of all the mass of the Earth would be zero.

To find ΔGPE, calculate area under the graph.

When calculating the area under the graph, be mindful of the units. (F-d: don't multiply by mass, GFS-d: multiply by mass) *Joules = N*m*

Electric field and force are constant in parallel plates and change in distance between the plates doesn't affect voltage.

DC motors convert electrical energy into rotational kinetic energy (rotational motion)

If a charge moves in the direction, it would naturally go (e.g., a positive charge moving towards a negative source), the electric field does work on the charge.

If a charge is forced to move against its natural direction, work must be done on the electric field.

If current flows parallel in the same direction as the magnetic field, the force is zero.

Parallel wires - Current flowing in the same direction attracts while opposite directions repel.

A split-ring commutator's function is to reverse the direction of the current in the coil every half rotation. This reversal ensures the torque continues to act in the same rotational direction, allowing for continuous spinning instead of just oscillating back and forth.

In particle accelerators, electric field control the kinetic energy and speed, whereas the magnetic field controls the direction, as it acts perpendicular to the velocity.

The magnitude of torque experienced by the coil is at its maximum value when the coil is parallel with the magnetic field.

The magnitude of torque is zero when; the plane of the coil is perpendicular to the direction of the magnetic field.

The split-ring commutator reverses the direction of current flow within the rotating coil every half turn, precisely when the coil passes the vertical position, it ensures that the forces acting on the sides of the coil always produce a torque that drives the motor continuously in the same direction. Without it, the torque would reverse every half-turn, preventing continuous rotation.

A solenoid acts like a bar magnet, with a distinct North and South pole. Field lines on the outside act much like the field lines on a bar magnet. With field lines on the inside being straight and parallel.

The field strength of a solenoid can be increased by current or turn density.

Dots are assumed as towards you (i.e. out of the page) & crosses as away from you (i.e. into the page).

According to the right-hand slap rule moving charged particles within a magnetic field will always move in a circular arc as the magnetic force acting on them is constant & perpendicular to the direction of motion.

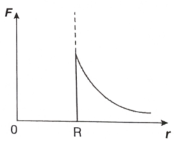
Your palm would indicate the force direction for a positive charge. Since the electron is negative, the force (FB) is in the exact opposite direction to where your palm faces. The proton will curve in the direction your palm is pushing.

Example Questions

Find the expression for the altitude above Earth's surface (radius R) where the gravitational field strength is half its surface value.

$= (\sqrt{2}R) - R$

A hollow satellite with all its mass, M, located at a radius R from its centre. What graph best represents the force of gravity experienced by an astronaut at a distance r($0 < r < \infty$) from the centre of the satellite?



Explain why geostationary satellites must be vertically above the equator to remain stationary relative to Earth's surface.

All orbits must be centred on Earth's centre of mass due to gravity. The only orbital path centred on Earth's core that also perfectly matches the Earth's surface rotation without any north-south drift is an orbit directly above the equator. Any other inclination would cause the satellite to move north or south relative to the ground observer.

What would happen if the split ring in a DC motor was replaced with a slip ring.

Instead of continuous rotation in one direction, the motor would:

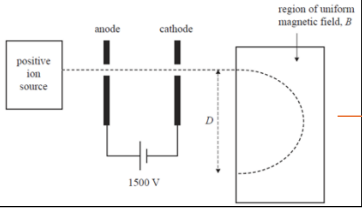
Rotate approximately half a turn (180 degrees) due to the initial torque.

Then, experience a reversing torque that opposes the rotation.

The motor would likely oscillate back and forth around the vertical position where the torque changes direction. It might rock a bit past the vertical due to inertia, but the reversed torque would quickly push it back.

A schematic diagram of a mass spectrometer that is used to deflect charged particles to determine their mass is shown below. Positive singly charged ions (with a charge of $1.6 * 10^{-19}C$) are produced at the ion source. These are accelerated between an anode and a cathode. The potential difference between the anode and the cathode is 1500 V. The ions pass into a region of uniform magnetic field, B, and are directed by the field into a semicircular path of diameter D.

Each ion has a mass of $4.80 \times 10^{-27}\ kg$.



2 large isolated parallel metal plates are placed at distance, *d*, apart.

What happens to the magnitude of the electric field midway between the plates if d is halved?

The electric field increase by a factor of 2.

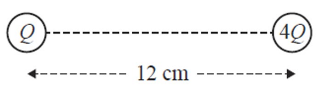
What happens to the magnitude of the potential difference between the two plates if d is doubled.

The voltage has not changed.

Calculate the magnitude and direction of the electric field that would be required for an electron to travel through undeflected. (at a velocity of 1.1*10^7 and magnetic field strength of 1*10^4)

$E = vB = (1.1 * 10^7) * (1 * 10^4) = 10^{11}NC^{-1}$

Two point charges, Q and 4Q, are placed 12 cm apart, as shown in the diagram below.

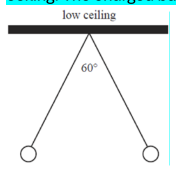


On the straight line between the charges Q and 4Q, the electric field is

Zero at a point 4 cm from Q.

$$\frac{kQ}{r^2} = \frac{k4Q}{(12-r)^2} \Longrightarrow r = 4$$

Two equally charged balls, each of mass 4.0 g , from light, non-conducting strings suspended from a low ceiling. The charged balls repel each other with the strings at an angle of 60°, as shown below.



Show that the tension force, T, in each string is 4.5 × 10−2 N. Use g = 9.8 N kg−1.

Solve using $T\cos 30 = F_g$

Calculate the magnitude of the electrostatic force, FE . Show your working.

Solve using $T\sin 30 = F_E$

The region of uniform magnetic field, B, (above) has a magnitude of 0.10 T. Calculate the diameter, D.

$$r = \frac{mv}{qB} = \frac{(4.80 * 10^{-27}) * (3.16 * 10^5)}{(1.6 * 10^{-19}) * 0.10} = 9.4 * 10^{-2} \qquad v = \sqrt{\frac{2qV}{m}} = 3.16 * 10^5$$