Science 30	Unit C: Physics
Lesson 2 - Field Strength	84 mins

Gravitational Field Strength

gravitational constant 6.67×10^{-11} N•m^2/kg^2

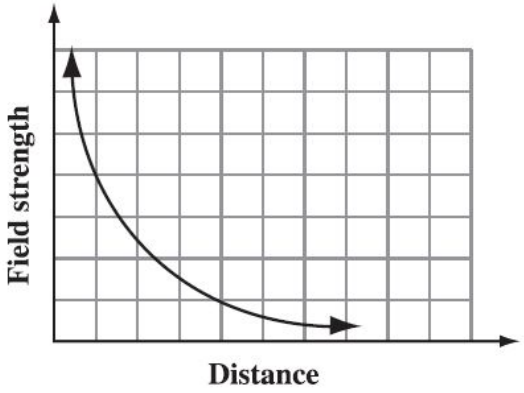
mass of source (kg)

$$g = \frac{Gm}{r^2}$$

gravitational field strength (N/kg)

distance from centre of source (m)

As distance increases gravitational field strength decreases by A LOT



Example Problem 1.5

The Moon has an average radius of 1.74×10^3 km and a mass of 7.35×10^{22} kg.

a. Calculate the gravitational field strength of the Moon.

b. Explain why the Moon has a different value for gravitational field strength than Earth does.

c. An astronaut in a new lightweight spacesuit has a mass of 100 kg and could be considered a test body for the gravitational field of the Moon. Determine the force of gravity exerted on the astronaut by the Moon's gravitational field.

Solution

a. $r = 1.74\times10^3 \text{ km} \times \frac{1000 \text{ m}}{1 \text{ km}}$

$= 1.74\times10^6$ m

Note: Kilometres are converted to metres before the values are substituted in the equation.

$m_{source} = 7.35\times10^{22}$ kg

$g = ?$

$$g = \frac{Gm_{source}}{r^2}$$

$$= \frac{(6.67\times10^{-11} \text{ N•m}^2/\text{kg}^2)(7.35\times10^{22} \text{ kg})}{(1.74\times10^6 \text{ m})^2}$$

$= 1.619\,252\,874$ N/kg

$= 1.62$ N/kg

The strength of the gravitational field at the Moon's surface is 1.62 N/kg.

b. Gravitational field strength depends upon two key variables: m, the mass of the source, and r, the distance from the centre of the source. Since both of these values are significantly different from the values for Earth, the Moon has a different value for gravitational field strength.

c. $g = 1.619\,252\,874$ N/kg

$m_{test} = 100$ kg

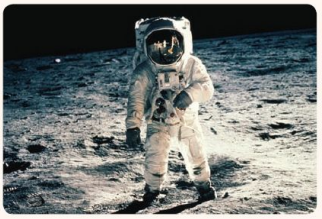
$F_g = ?$

$F_g = m_{test}g$

$= (100 \text{ kg})(1.619\,252\,874 \text{ N/kg})$

$= 162$ N

Using the value from part a., the Moon's gravitational field will exert a force of 162 N on the astronaut.



Electric Field Strength

electric field strength (N/C)

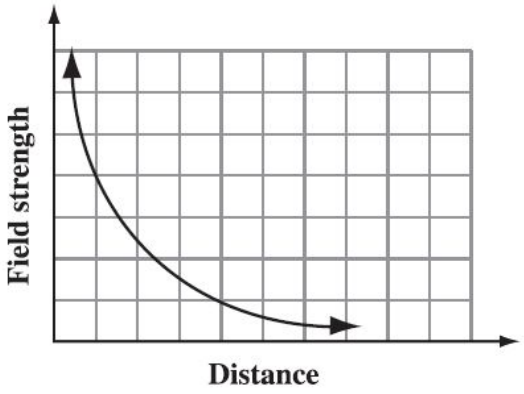
coulomb constant 8.99×10^9 N•m^2/C^2

$$|\vec{E}| = \frac{kq}{r^2}$$

charge on source (C)

distance from centre of source

As distance increases Electric Field Strength decreases by A LOT



A balloon is given a charge of -4.5 nC.

a. Determine the electric field strength 30 cm from the centre of the balloon.

b. Sketch a diagram of the electric field lines around the balloon.

Solution

a. $q_{source} = -4.5$ nC

$= -4.5\times10^{-9}$ C

$d = 30 \text{ cm} \times \frac{1 \text{ m}}{100 \text{ cm}}$

$= 0.30$ m

$|\vec{E}| = ?$

The negative sign is not used in the equation. The negative sign is used to determine direction in part b.

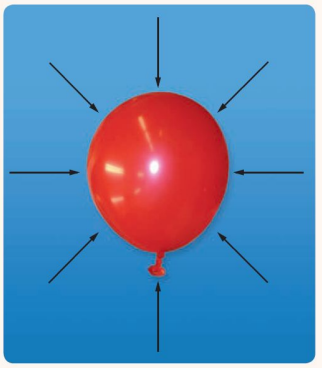
$$|\vec{E}| = \frac{kq_{source}}{r^2}$$

$$= \frac{(8.99\times10^9 \text{ N•m}^2/\text{C}^2)(4.5\times10^{-9} \text{ C})}{(0.30 \text{ m})^2}$$

$= 4.5\times10^2$ N/C

The electric field strength 30 cm from the balloon's centre is 4.5×10^2 N/C.

b. Since the direction of the electric field is determined by the force on a positive test body, the electric field lines are directed toward the negatively charged balloon.



Science 30 - Lesson 26 - Unit C - Field Strength

Name: _____

1) **Gravitational Field Strength Example**
   The Moon has an average radius of 1.74×10^3 km and a mass of 7.35×10^{22} kg.
   a) Calculate the gravitational field strength of the Moon.

   b) Explain why the Moon has a different value for gravitational field strength than Earth does.
   (g_{earth} = 9.83 N/Kg)

   c) An astronaut in a new lightweight space suit has a mass of 100 kg and could be considered a test body for the gravitational field of the Moon. Determine the force of gravity exerted on the astronaut by the Moon's gravitational field.

2) **Electric Field Strength Example**
   A balloon is given a charge of - 4.5 nC.
   a) Determine the electric field strength 30 cm from the centre of the balloon.

   b) Sketch a diagram of the electric field lines around the balloon.

3) Calculate the gravitational field strength on the surface of each of the following objects:
   a) Mars has a mass of 6.42×10^{23} kg and an average radius of 3.40×10^3 km.

   b) Io, one of Jupiter's moons, has a mass of 8.94×10^{22} kg and an average radius of 1.82×10^3 km.

c) Determine the force of gravity of an astronaut on the surfaces of Mars and Io if the mass of the astronaut is 100 kg.

d) Identify the key features of each object that account for the differences in your previous answers.

4) Calculate the electric field strength on the surface of each of the following objects, then sketch a diagram of the electric field lines around each of the objects:
   a) A student's hair stands on end as she touches the globe of a van de Graaff generator. The charge on the globe is +3.5 μC and it has a radius of 18 cm.

   b) A large balloon with a charge of - 4.7 nC has a radius of 17 cm.

5) All magnetic fields have a similar shape. Draw a simple diagram to illustrate how this statement applies to each of the following sources of **magnetic** fields.

a current-carrying coil	**a permanent magnet**	**Earth**