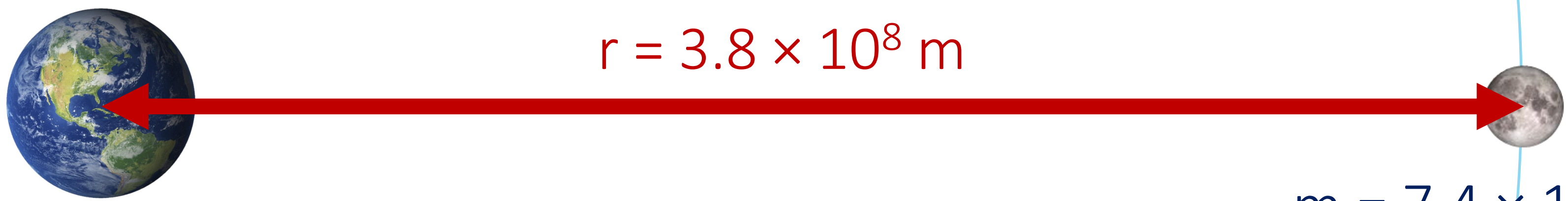
Force Fields

IB PHYSICS | FORCE FIELDS

Warm Up

What is the force of gravity between the earth and the moon?



m = 6×10^{24} kg

m = 7.4×10^{22} kg

$$F = (6.67 \times 10^{-11}) \frac{(6 \times 10^{24})(7.4 \times 10^{22})}{(3.8 \times 10^{8})^2}$$

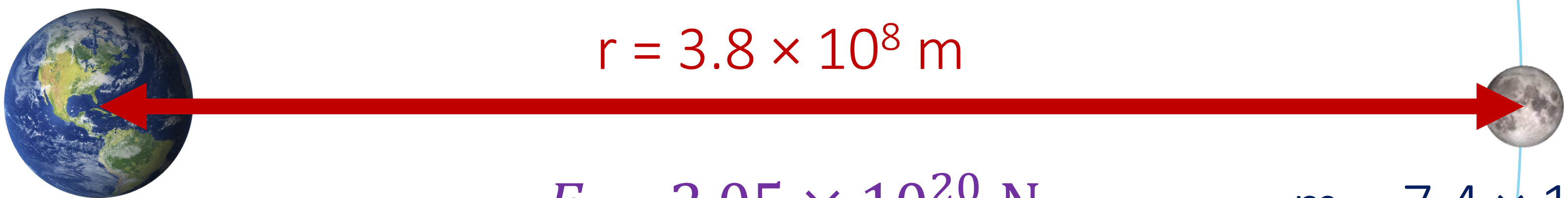
$$\boxed{F = 2.05 \times 10^{20}\ \mathrm{N}}$$

$$F = G\frac{Mm}{r^2}$$

G = 6.67×10^{-11} N m^2 kg^{-2}

Review of Circular Motion

How fast (in m/s) is the moon moving?



r = 3.8 × 10^{8} m

$F = 2.05 \times 10^{20}\ \mathrm{N}$

m = 6 × 10^{24} kg

m = 7.4 × 10^{22} kg

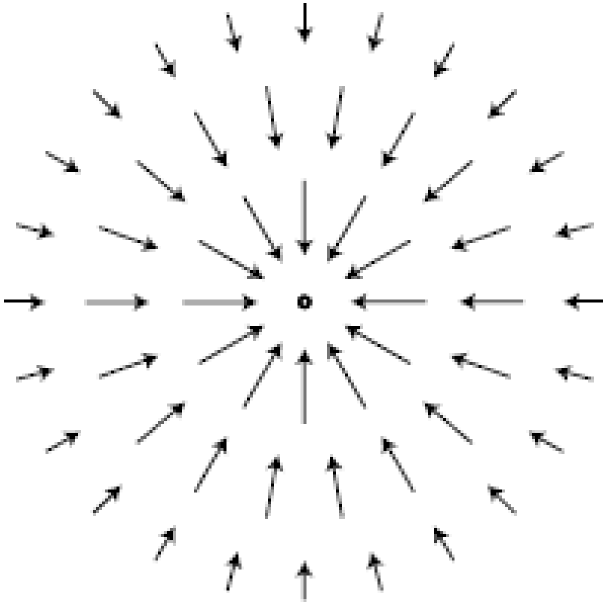
$$2.05 \times 10^{20} = \frac{(7.4 \times 10^{22})v^2}{(3.8 \times 10^{8})}$$

$$v = 1026\ \mathrm{m\ s^{-1}}$$

$$F = \frac{mv^2}{r} = m\omega^2 r$$

Force Fields

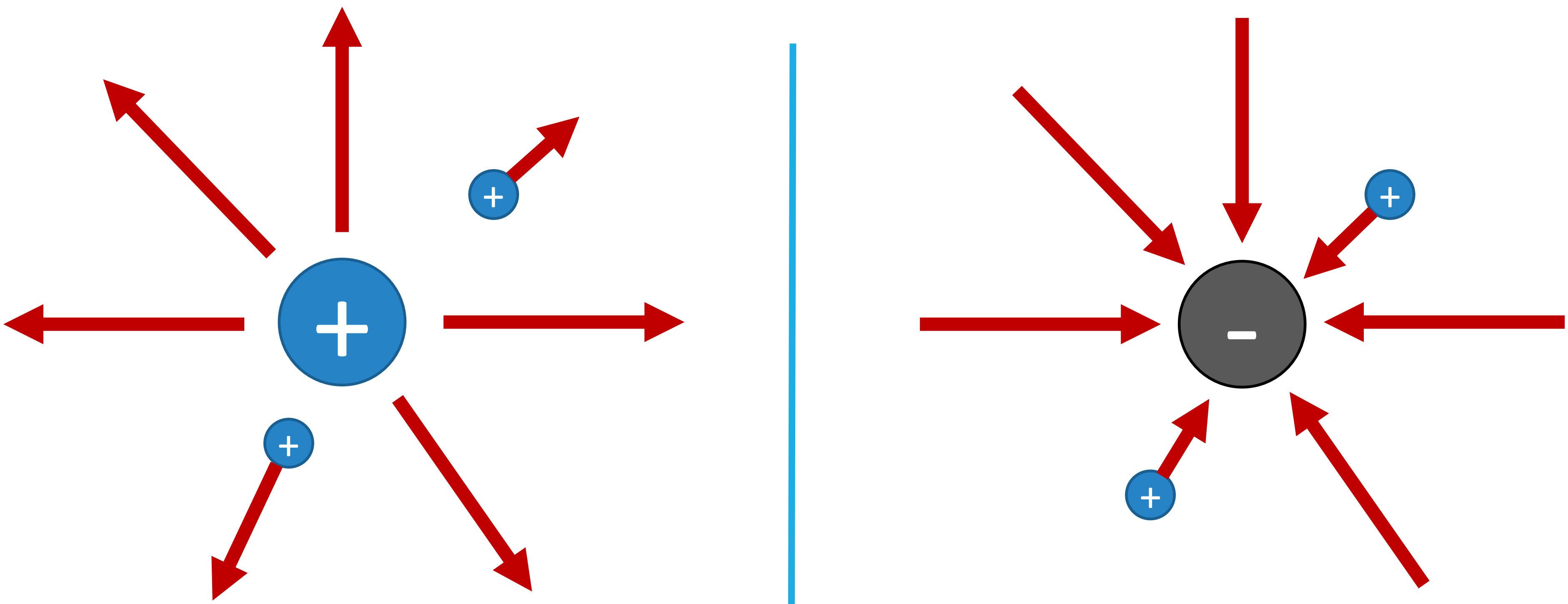
Vector field that describes the force that would act on a particle at various positions



	Electric Field	Gravitational Field
Symbol	$\boldsymbol{E}$	$\boldsymbol{g}$
Unit	$\frac{\mathrm{N}}{\mathrm{C}} = \mathrm{N\ C^{-1}}$	$\frac{\mathrm{N}}{\mathrm{kg}} = \mathrm{N\ kg^{-1}}$

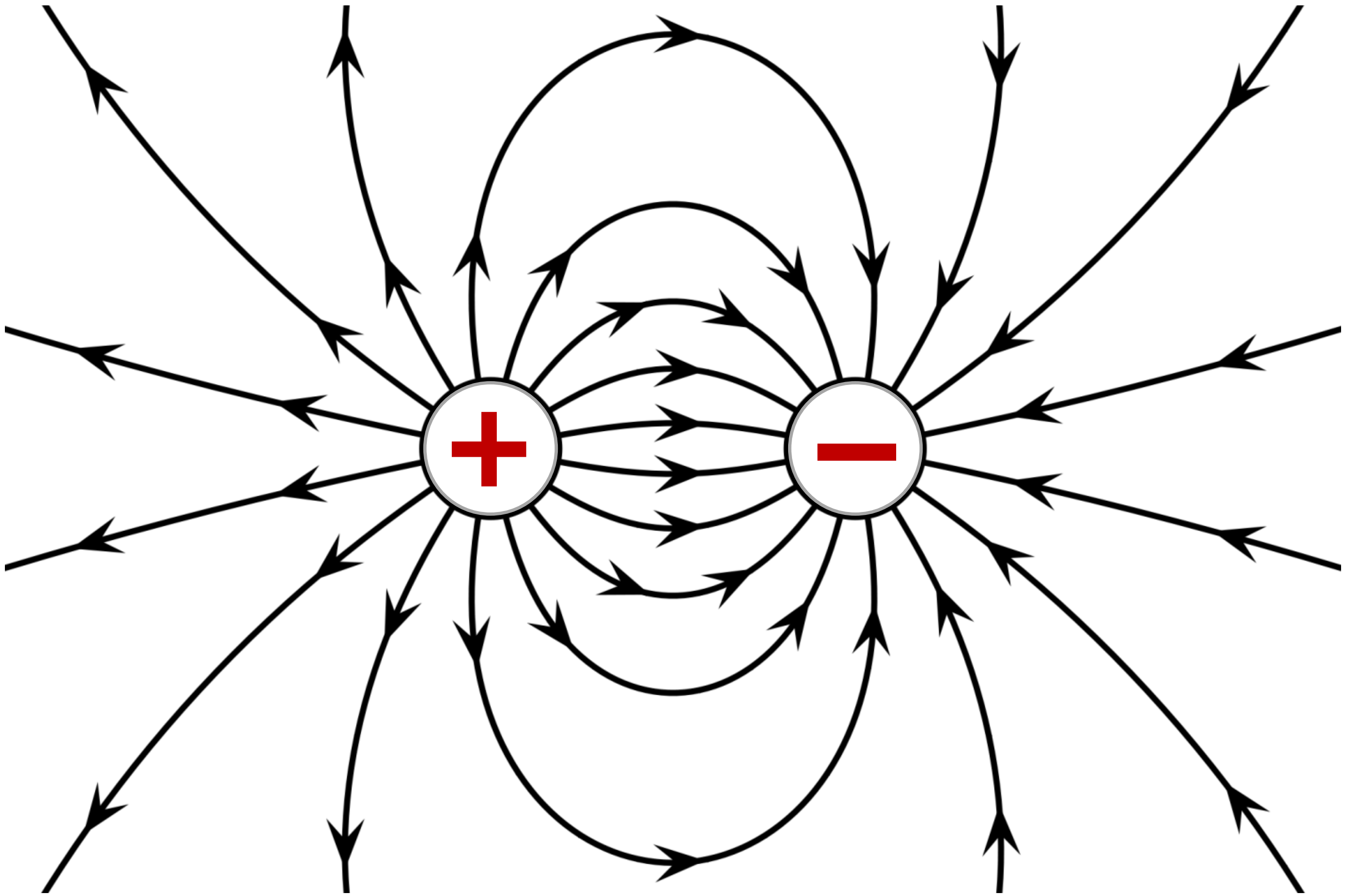
Electric Fields

Electric Fields point in the direction that a __positive___ charge would travel



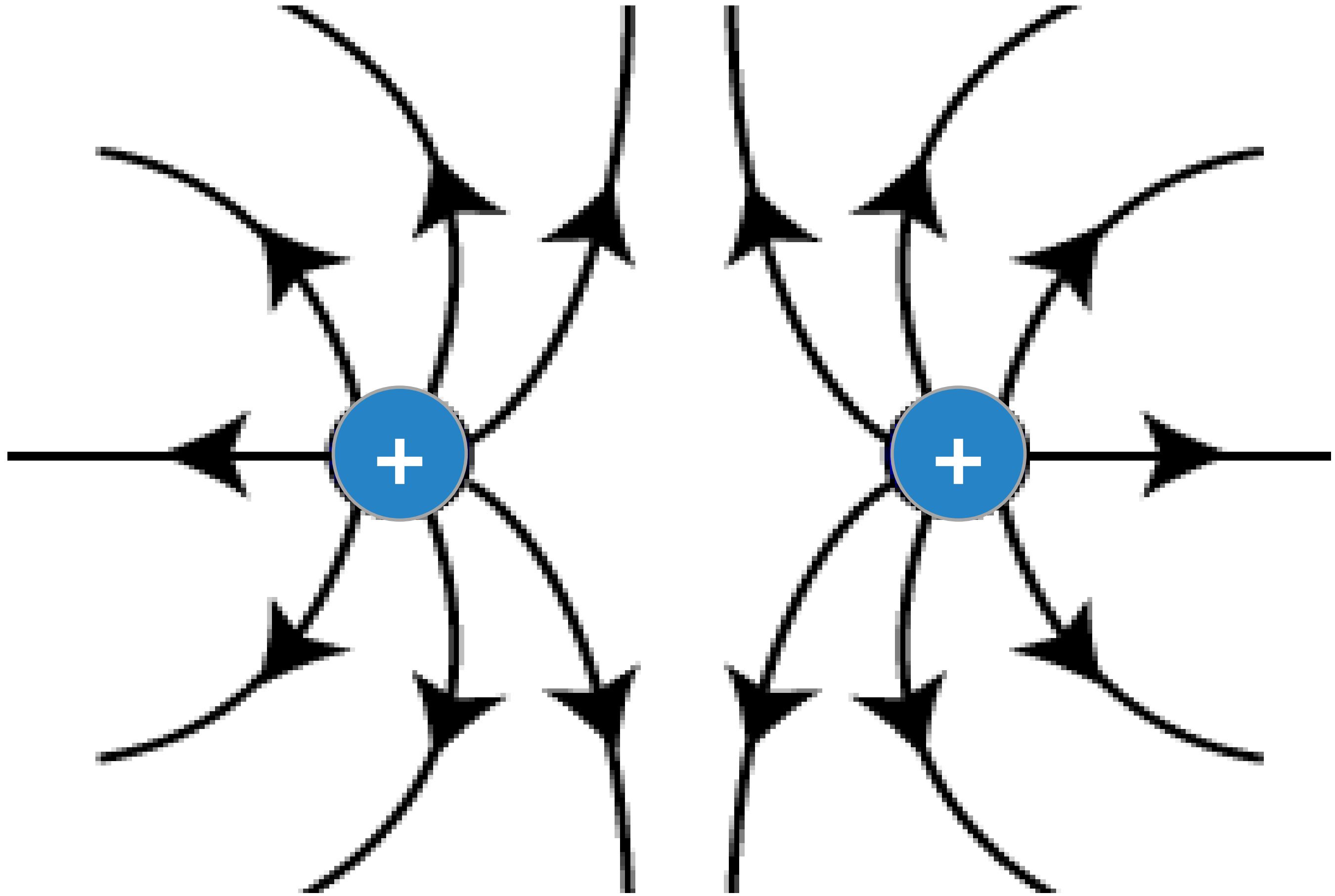
Try This

Label these charges as positive (+) or negative (-)

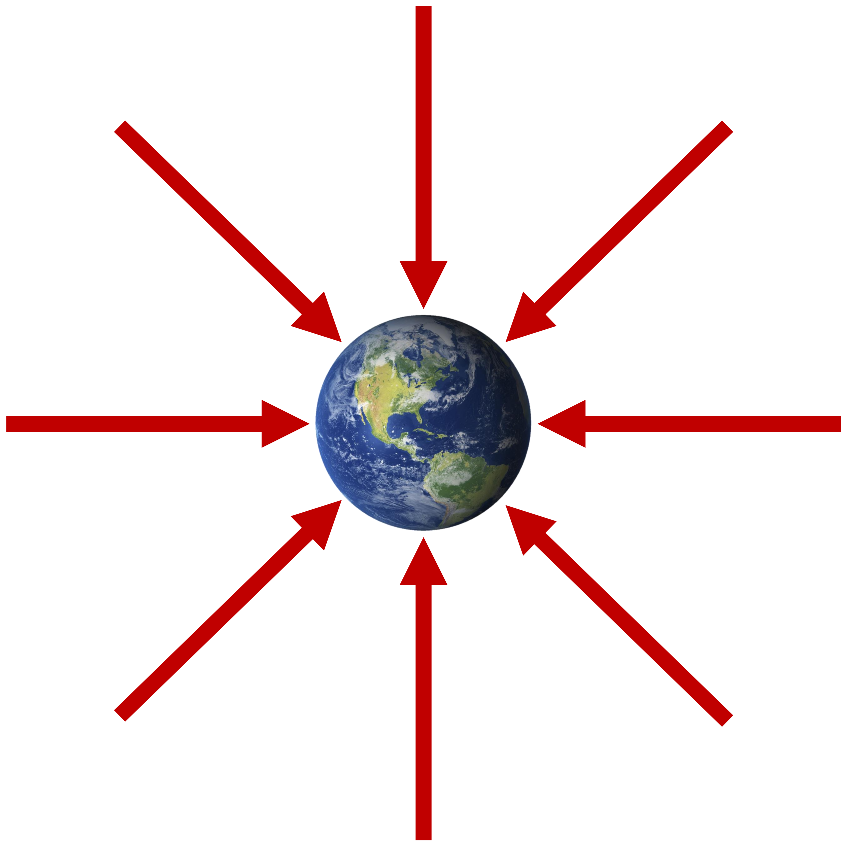


Try This

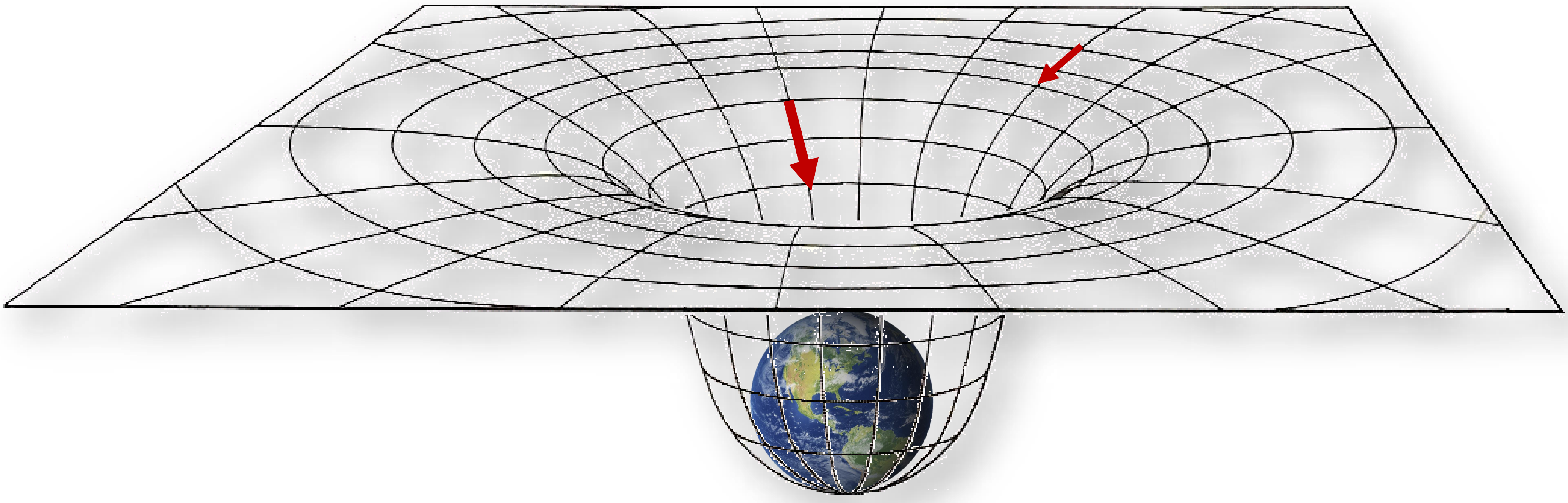
Predict what the field lines will look like:



Gravity as a field



Gravity as a field

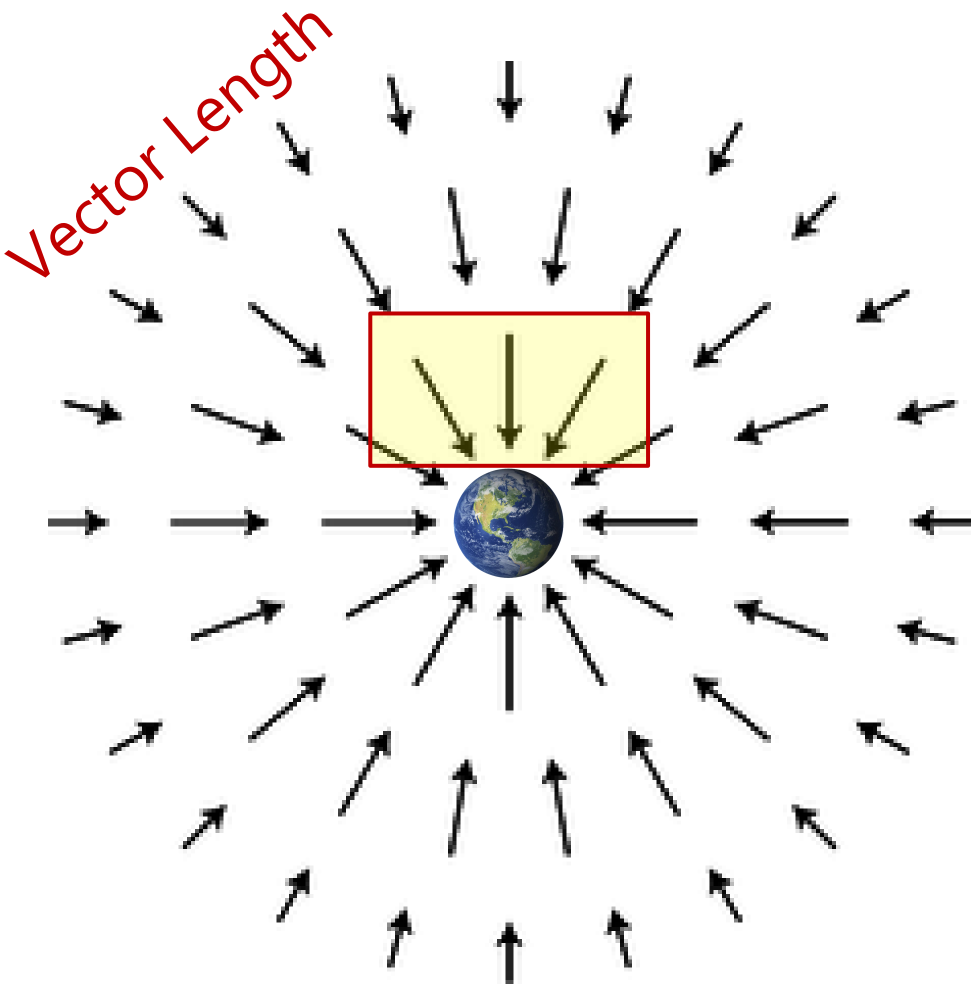


Gravity as a field

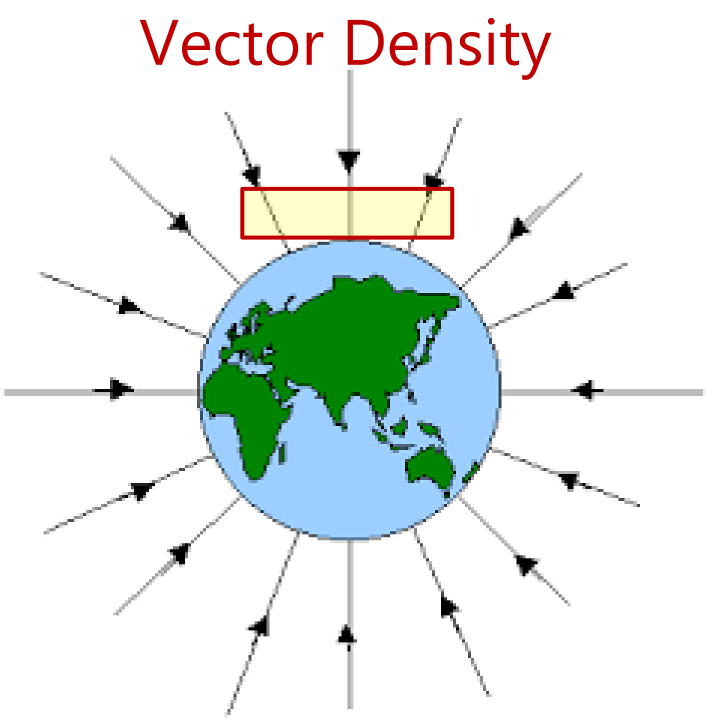
- The gravitational field distorts the space around the mass that is causing it so that any other mass placed at any position in the field will "know" how to respond immediately.

- Bigger masses "curve" the rubber sheet more than smaller masses.

Gravity as a field



How do we visually represent the strength of the field?



IB Physics Data Booklet

Sub-topic 5.1 – Electric fields
$I = \frac{\Delta q}{\Delta t}$
$F = k\frac{q_1 q_2}{r^2}$
$k = \frac{1}{4\pi\varepsilon_0}$
$V = \frac{W}{q}$
$\boxed{E = \frac{F}{q}}$
$I = nAvq$

Sub-topic 5.3 – Electric cells
$\varepsilon = I(R + r)$

Sub-topic 6.2 – Newton's law of gravitation
$F = G\frac{Mm}{r^2}$
$\boxed{g = \frac{F}{m}}$
$\boxed{g = G\frac{M}{r^2}}$

Remember g?

$$g = 9.81 \text{ m s}^{-2}$$

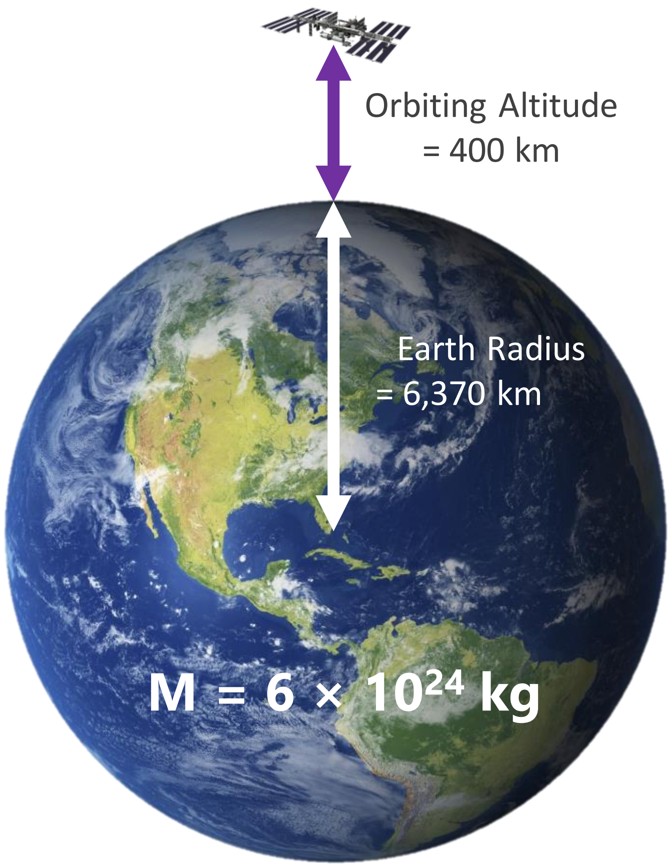
g representing acceleration is not the whole story…

g → Gravitational Field Strength

$$g = \frac{\mathrm{N}}{\mathrm{kg}} = \frac{\cancel{\mathrm{kg}} \times \mathrm{m\,s}^{-2}}{\cancel{\mathrm{kg}}} = \mathrm{m\,s}^{-2}$$

Wait, does that mean g changes?

$400\ km + 6370\ km = 6770\ km$

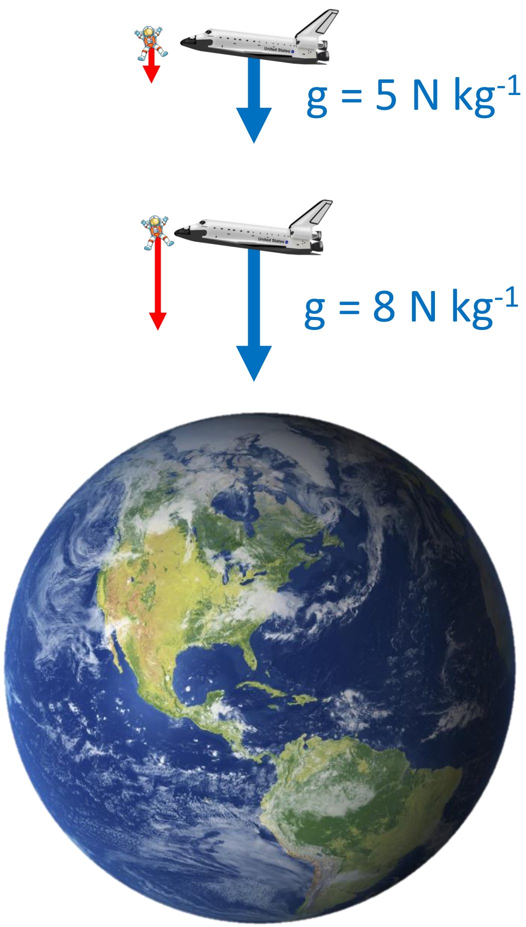


$$g = G\frac{M}{r^2}$$

$$g = G\frac{M}{r^2} = (6.67 \times 10^{-11})\frac{(6 \times 10^{24})}{(6{,}770{,}000)^2}$$

$$\boxed{g = 8.73\ \mathrm{N\ kg^{-1}}}$$

Using g



= 2,000,000 kg

= 75 kg

What is the force of gravity for each position?

$$F = (75\ kg)(5\ N\ kg^{-1})$$
$$F = \mathbf{375\ N}$$

$$F = (2{,}000{,}000\ kg)(5\ N\ kg^{-1})$$
$$F = \mathbf{10{,}000{,}000\ N}$$

$$F = (75\ kg)(8\ N\ kg^{-1})$$
$$F = \mathbf{600\ N}$$

$$F = (2{,}000{,}000\ kg)(8\ N\ kg^{-1})$$
$$F = \mathbf{16{,}000{,}000\ N}$$

Try This

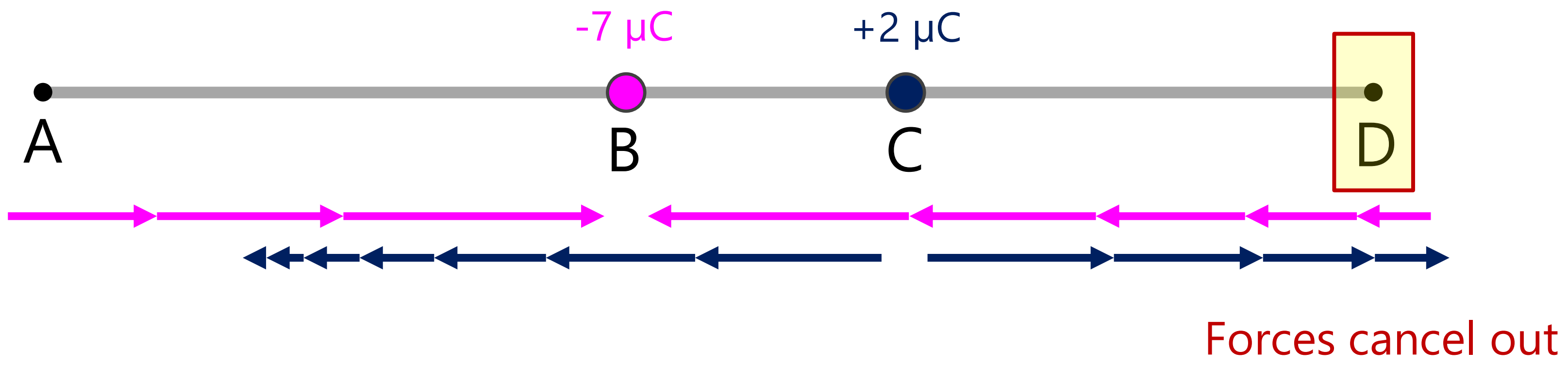
What is the electric field strength if a particle with a charge of +6.3 μC experiences a force of 0.0025 N?

$$E = \frac{F}{q} = \frac{0.0025\ \mathrm{N}}{6.3 \times 10^{-6}\ \mathrm{C}}$$

$$\boxed{E = 397\ \mathrm{N\ C^{-1}}}$$

Think about this...

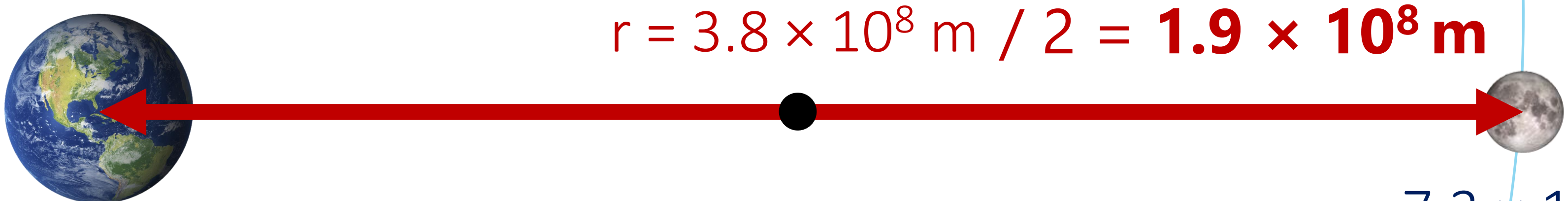
Two isolated point charges, –7 μC and +2 μC, are at a fixed distance apart. At which point is it possible for the electric field strength to be zero?



Try this

What is the gravitational field strength halfway between the centers of the earth and the moon?

r = 3.8×10^8 m / 2 = **1.9×10^8 m**



m = 6×10^{24} kg

m = 7.3×10^{22} kg

$$g = (6.67 \times 10^{-11}) \frac{(6 \times 10^{24})}{(1.9 \times 10^{8})^2} = \mathbf{0.011\ N\ kg^{-1}}$$

$$g = (6.67 \times 10^{-11}) \frac{(7.3 \times 10^{22})}{(1.9 \times 10^{8})^2} = \mathbf{0.00013\ N\ kg^{-1}}$$

$$g = 0.011 - 0.00013 =$$

$$\boxed{g = 0.0109\ \mathrm{N\ kg^{-1}}}$$

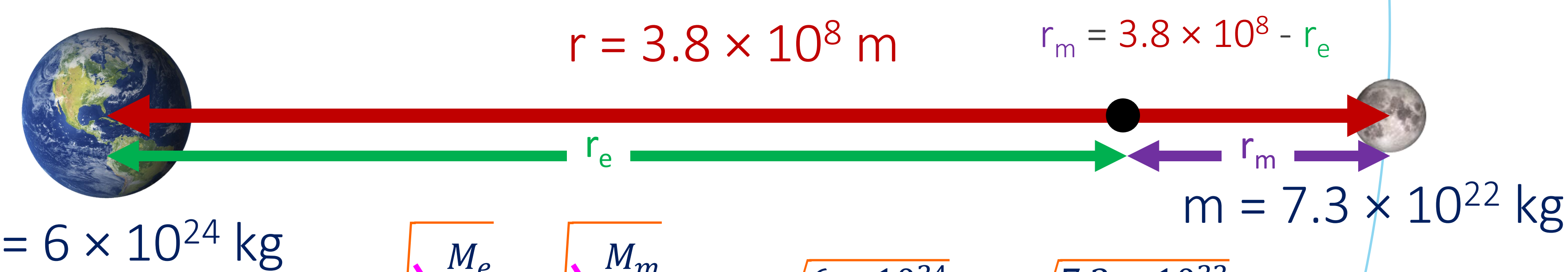
$$g = G\frac{M}{r^2}$$

G = $6.67 \times 10^{-11}\ \frac{N \times m^2}{kg^2}$

Try this

Where would an object experience a gravitational field of 0 N kg^{-1}

$$G\frac{M_e}{{r_e}^2} = G\frac{M_m}{{r_m}^2}$$



cancel out G
and
square root everything

$$\sqrt{\cancel{G}\frac{M_e}{{r_e}^2}} = \sqrt{\cancel{G}\frac{M_m}{{r_m}^2}}$$

$$\frac{\sqrt{M_e}}{r_e} = \frac{\sqrt{M_m}}{r_m}$$

$$\frac{\sqrt{6\times10^{24}}}{r_e} = \frac{\sqrt{7.3\times10^{22}}}{(3.8\times10^{8} - r_e)}$$

$$(9.31\times10^{20}) - (2.45\times10^{12})r_e = (2.70\times10^{11})r_e$$

$$(9.31\times10^{20}) = (2.72\times10^{12})r_e$$

$$\boxed{r_e = 3.42\times10^{8}\ \mathrm{m}}$$

$$g = G\frac{M}{r^2}$$

G = 6.67 × 10^{-11} $\frac{N\times m^2}{kg^2}$