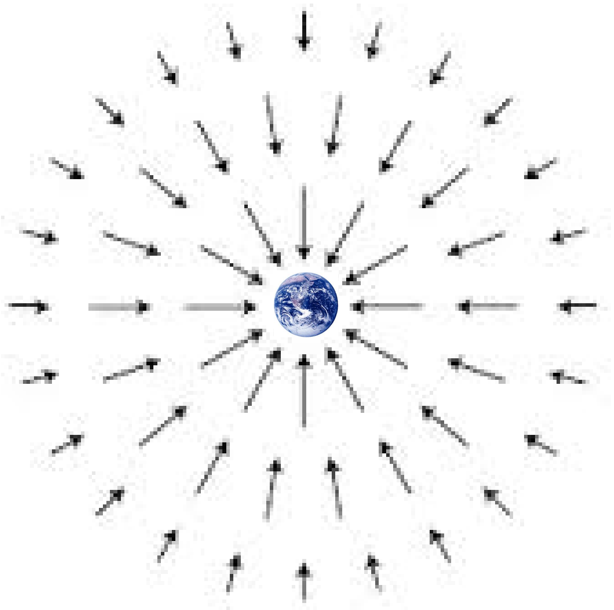
L02 - Gravitational Fields

Agenda:

- Attendance
- Formative Quiz: Gravitational Forces
- Gravitational Forces in 2-Dimensions
  - *- Multiple Bodies*
  - *- Instantaneous Acceleration*
- Exploring the "Inverse r^2" relationship.
  - *- Strength of Gravitational Force versus Distance*
  - *- Gravitational Fields*
  - *- Gravitational and Electrostatic Forces*
  - *- Gravitational Field Hockey?*

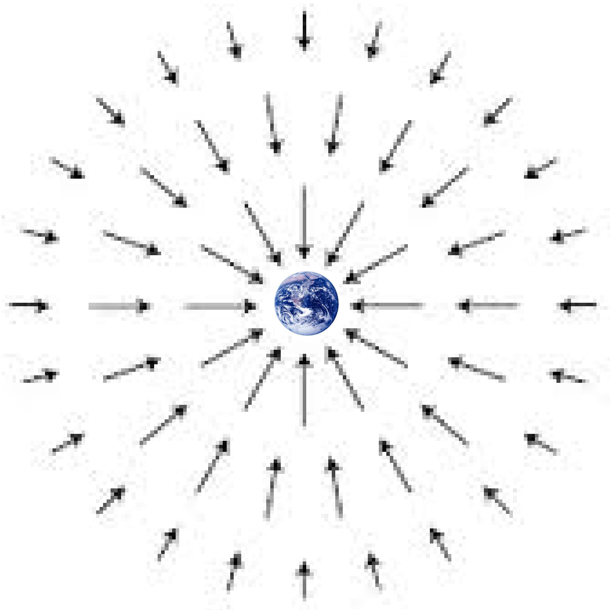


Gravitational Fields

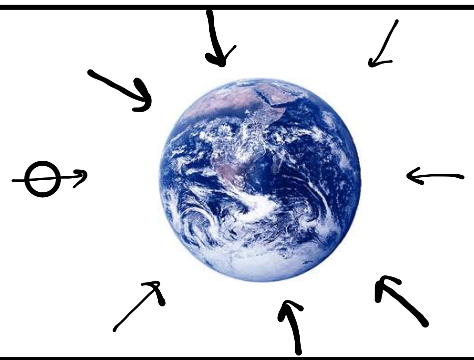
$F_g = \frac{Gm_Am_B}{r^2}$ $\quad g = \frac{GM_{source}}{r^2}$ $\quad where\ G = 6.67x10^{-11} \frac{Nm^2}{kg^2}$

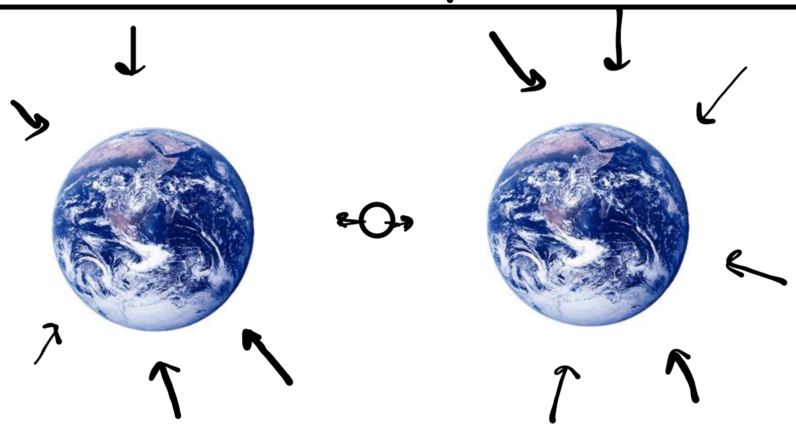
Gravitational Field Strength: The gravitational force per unit mass at a specific location.

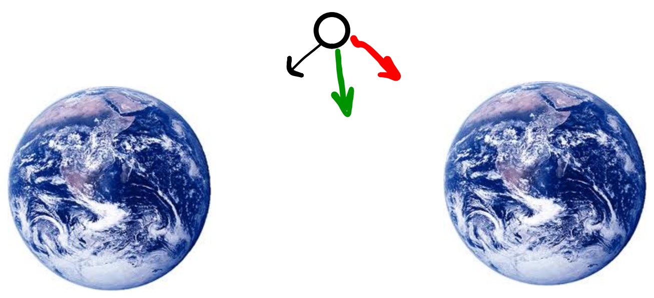
Gravitational Field: The area of influence surrounding an object.



Gravitational Field at Points in Space







Calculating Gravitational Fields

Case #1: Place a test object, with a known mass, in gravitational field and measure the force on the object.

$$\vec{g} = \frac{F_g}{m_{test}}$$

$F = mg$ (m: Mass of object; g: Grav. Field Strength of Source)

Q1: What is the acceleration due to gravity near the surface of the Moon if an object that has a mass of 22.0 kg has a weight of 36.0 N near the Moon's surface?

$m = 22$
$F = 36$

$g = \frac{F}{m}$

$g = \frac{36}{22}$

$g = 1.63\ N/kg$ → Grav. Field Strength

accel $= 1.63\ m/s^2$ → $F_g = mg$

Case #2: Know the distance from the source and the mass of the source.

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

$F_g = \frac{Gm_{source} m_{test}}{r^2}$ ("g" $= \frac{Gm_{source}}{r^2}$)

$F_g = g_{source} m_{test}$

$F_g = mg$

Q2: Calculate the magnitude of the gravitational field on an object at the equator on the surface of Earth, if the mass of the earth is 5.97×10^{24} kg and the radius is 6.38×10^{6} m.

$$g = \frac{Gm_s}{r^2} = \frac{(6.67\times10^{-11})(5.97\times10^{24})}{(6.38\times10^{6})^2} = \frac{3.98199\times10^{14}}{4.07044\times10^{13}} = 9.78\ N/kg$$

$\approx 9.81\ m/s^2$

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Gravitational Field and Force Equations - Relation?

$F_g = \frac{G m_A m_B}{r^2}$ $g = \frac{G M_{source}}{r^2}$ where $G = 6.67x10^{-11} \frac{Nm^2}{kg^2}$

On Earth, m_{Earth} = 5.97 x 10^{24} kg, m_{Nunzio} = 6.35 kg, and r_{Earth} = 6.371 x 10^6 m.

Q3: Calculate the Gravitational Field Strength that Nunzio experiences.

$\vec{g} = \frac{G m_{source}}{r^2}$

$g = 9.78$ N/kg (Prev slide)

Q4: Calculate the Gravitational Force on Nunzio using two (2) different methods.

$m_E = 5.97 \times 10^{24}$
$m_N = 6.35$
$r_E = 6.371 \times 10^6$

(A) $F_g = \frac{G m_E m_N}{r^2}$

$= \frac{(6.67\times10^{-11})(5.97\times10^{24})(6.35)}{(6.371\times10^6)^2}$

$= \frac{2.5285...\times10^{15}}{4.05896...\times10^{13}}$

$= 62.3$ N

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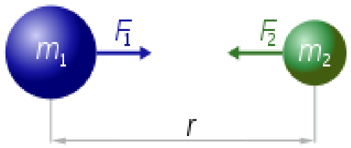
(B) $F_g = mg$

$= (6.35)(9.81)$

$= 62.3$ N

The "Inverse r²" Relationship

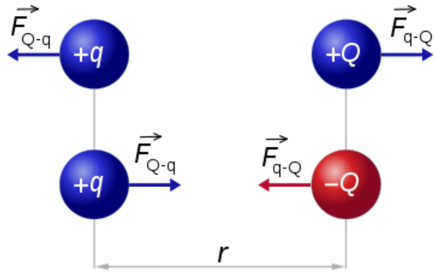
Gravitational Force



$$F = G\frac{m_1 m_2}{r^2},$$

$$G \approx 6.674 \times 10^{-11}\ \mathrm{N\,(m/kg)^2}$$

Electrostatic Force

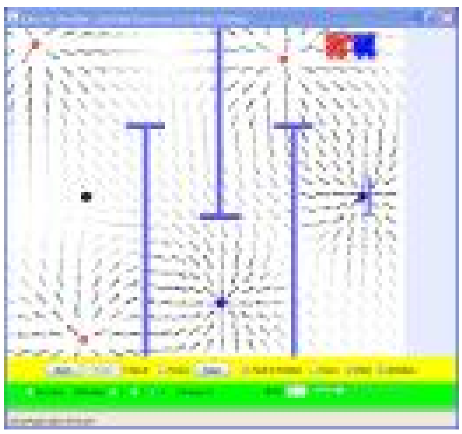


$$F = k_e\frac{q_1 q_2}{r^2}$$

$$k_e = \frac{1}{4\pi\varepsilon_0} = \frac{c^2\ \mu_0}{4\pi} = c^2 \cdot 10^{-7}\ \mathrm{H \cdot m^{-1}}$$
$$= 8.987\ 551\ 787\ 368\ 176\ 4 \times 10^9\ \mathrm{N \cdot m^2/C^2}$$

Similarities? Differences?

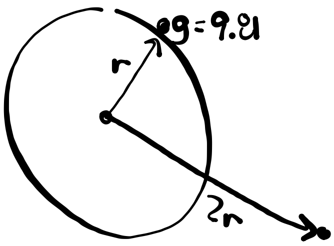
http://phet.colorado.edu/en/simulation/electric-hockey



Electric Field Hockey

Practice

Check and Reflect P. 229 #5, 7, 12 (read page 222)



$g = \frac{Gm_s}{(2r)^2}$

$g = 9.81$

$g_{new} = \frac{Gm_E}{(2r)^2} = \frac{1}{4}\left(\frac{Gm_E}{r^2}\right) = \frac{1}{4}(9.81)$

$Fg_{new} = \frac{G(2m_1)m_2}{(3r)^2}$