Teachers' notes

Lesson notes

Gravitational Fields

1) Students will be able to describe a field as a concept used to make predictions regarding forces that act at a distance.

Evaluation

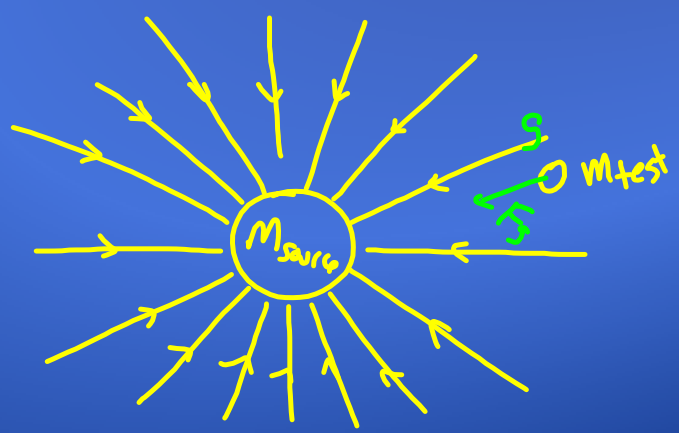
If a force is a push or a pull, why do we experience forces like gravity when nothing is actually making physical contact with us?

Gravity is an "action-at-a-distance" force...its effect can be experienced over large distances.

Gravitational Fields:

In physics, a field is a 3D area of influence surrounding an object or area.

A gravitational field is an area of influence around a "source" mass. In this area, a second object can experience a F_g.



The gravitational field strength is defined as:

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

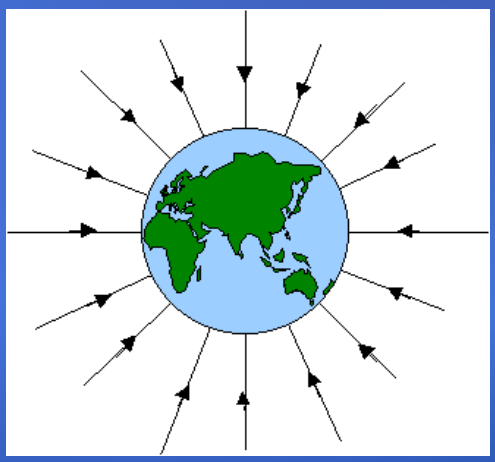
gravitational field strength (N/kg)

force of gravity felt by a test mass (N)

mass of test object "feeling" F_g (kg)

We can draw *field lines*, which indicate the strength and the direction of the gravitational field.

The field lines go towards the mass.
More lines = stronger field.



How can we calculate the gravitational field out in space, where we're farther away from the object that creates the gravitational field?

$$F_g = F_g$$

since $F_g = mg$

since $F_g = \frac{G m_{test} m_{source}}{r^2}$

$$\cancel{m_t} g = \frac{G \cancel{m_t} m_s}{r^2}$$

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

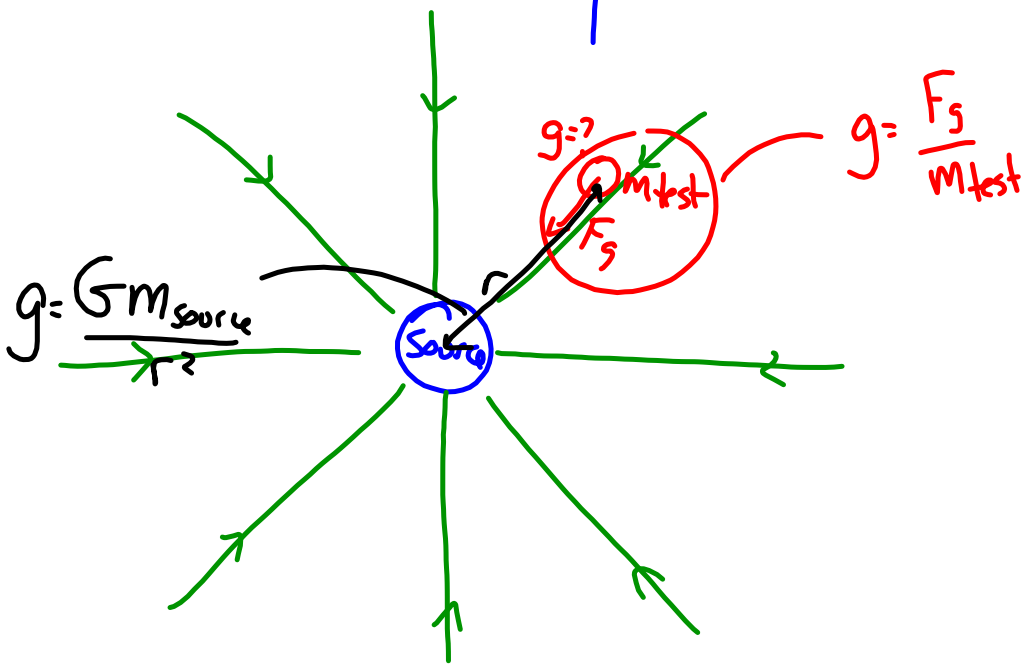
2 formulae describing the same thing:

g As described by a test object:

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

Self describing formula:

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



Example 4.5, p. 218

a. Calculate the magnitude of the gravitational acceleration of an object at the equator on the surface of Earth and the Moon.

b. Determine the ratio of g_{Earth} to g_{Moon}. How different would your weight be on the Moon?

a) $g_{moon} = ?$

$g_{earth} = ?$

$$g_{moon} = \frac{Gm_m}{r^2}$$

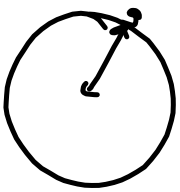
$$g_m = \frac{(6.67\times10^{-11})(7.35\times10^{22})}{(1.737\times10^{6}\,m)^2}$$

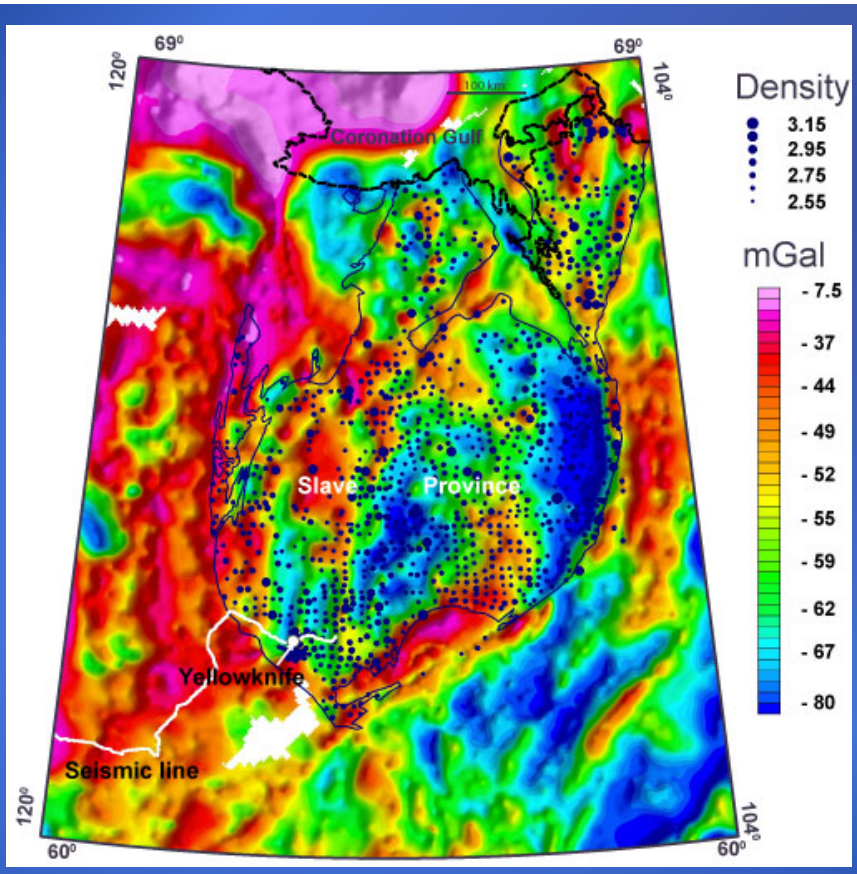
$$g = 1.62\ N/kg$$

$$g_e = \frac{Gm_e}{r^2}$$

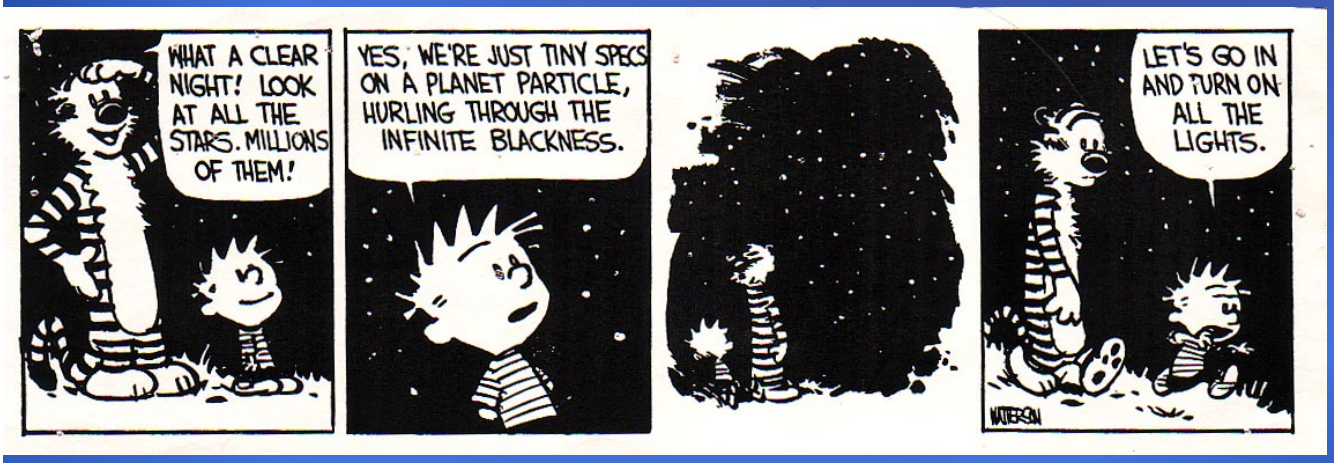
$$g_e = \frac{(6.67\times10^{-11})(5.97\times10^{24})}{(6.38\times10^{6}\,m)^2}$$

$$g_e = 9.78\ N/kg$$




69°
69°
120°
104°
100 km
Coronation Gulf
Density
3.15
2.95
2.75
2.55
mGal
- 7.5
- 37
- 44
- 49
- 52
- 55
- 59
- 62
- 67
- 80
Slave
Province
Yellowknife
Seismic line
120°
104°
60°
60°

Practice Problems, p. 219 #1-3



Example 4.6: p. 220

a). What is the mass of a 60.0 kg student on Mars and on Earth?

60 kg - mass doesn't change

b) What is the student's weight at the equator on the surface of Mars and of Earth?

$F_{gm} = ?$

$F_{gm} = \frac{G m_s m_m}{r^2}$

$F_{gm} = \frac{(6.67\times10^{-11})(60\,kg)(6.42\times10^{23})}{(3.40\times10^{6})^2}$

$F_{gm} = 222\,N$

$F_{ge} = ?$

$F_{ge} = \frac{G m_s m_e}{r^2}$

$F_{ge} = \frac{(6.67\times10^{-11})(60\,kg)(5.97\times10^{24})}{(6.38\times10^{6})^2}$

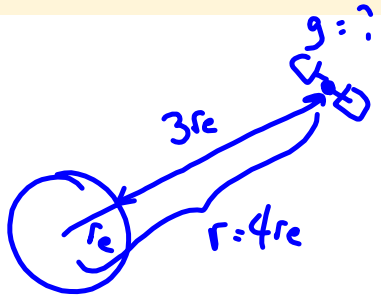
$F_{ge} = 587\,N$

Practice Problems, p. 219 #1-3

Practice Problems, p. 220, #1-3

1. A satellite orbits Earth at a distance of $3r_{\text{Earth}}$ above Earth's surface. Use the data from Table 4.1 on page 218.
   (a) How many Earth radii is the satellite from Earth's centre?
   (b) What is the magnitude of the gravitational acceleration of the satellite?

a)



b) $g = ?$

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

$$g = \frac{(6.67\times10^{-11}\ \text{Nm}^2/\text{kg}^2)(5.97\times10^{24}\ \text{kg})}{[4(6.38\times10^{6}\ \text{m})]^2}$$

$$g = 0.611\ \text{m/s}^2$$

3. The highest satellites orbit Earth at a distance of about $6.6r_{\text{Earth}}$ from Earth's centre. What would be the gravitational force on a 70-kg astronaut at this location?

$r = 6.6 r_e$

$F_g = ?$

$m_A = 70 kg$

$$F_g = \frac{G m_e m_A}{r^2}$$

$$F_g = \frac{(6.67 \times 10^{-11} Nm^2/kg^2)(5.97 \times 10^{24} kg)(70 kg)}{[(6.6)(6.38 \times 10^6 m)]^2}$$

$F_g = 16 N$

3. (a) What is the magnitude of the gravitational field strength at the equator on Uranus' surface?
(b) Compared to Earth, how would your weight change on Uranus?

a) $g = ?$

$m_U = 8.68 \times 10^{25}\ kg$

$r = 2.56 \times 10^{7}\ m$

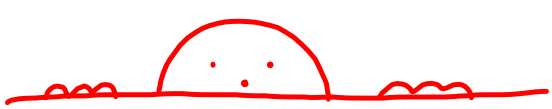
$$g = \frac{G m_U}{r^2}$$

$$g = \frac{(6.67 \times 10^{-11}\ Nm^2/kg^2)(8.68 \times 10^{25}\ kg)}{(2.56 \times 10^{7}\ m)^2}$$

$$g = 8.83\ N/kg$$

b)

$$\frac{8.83}{9.81} = .90$$



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