SPH3U UNIVERSITY PHYSICS

FORCES

- Gravitational Force Near Earth (P.162-164)

Gravitational Force Field

Recall that gravity is an action-at-a-distance force that pulls on objects (regardless of their size or mass) without making any contact with them. This occurs because Earth is surrounded by a gravitational force field. A ***force field*** *is a region of space surrounding an object that can exert a force on other objects. To represent the force field around Earth, we draw lines of force that point toward Earth's centre.*

Gravitational Force Field

NOTE!

All the vectors point toward Earth's centre, and their magnitudes indicate that the field becomes weaker as the distance from Earth's centre increases. As discussed earlier, it is the "direction toward the centre" that defines what we mean by "downward" on Earth's surface.

Gravitational Field Strength

*To determine the magnitude of Earth's gravitational force field at a particular location near its surface, physicists use a quantity called gravitational field strength. The **gravitational field strength** is the force per kilogram (N/kg) acting on an object within a gravitational field.*

NOTE!

At Earth's surface, the gravitational field strength, on average, is 9.8 N/kg[down].

Gravitational Field Strength – DYK?

Since Earth is not a perfect sphere, the magnitude of the gravitational field strength at Earth's surface varies according to geographic location. For example, at the North Pole the gravitational field strength is 9.8322 N/kg, whereas at the equator it is 9.7805 N/kg.

PRACTICE

1. What do you notice about the values 9.8 N/kg[d] and 9.8 m/s^2[d]?

   they are the same

Gravitational Field Strength – DYK?

PRACTICE

2. Show that units N/kg and m/s^2 are equivalent.

   recall N = $kg \cdot m/s^2$

Gravitational Field Strength

Since the gravitational field strength and the acceleration due to gravity are numerically equal, the same symbol, $\vec{g}$, is used for both.

GRAVITATIONAL FIELD STRENGTH ($\vec{g}$)

- force per unit mass acting on an object in a gravitational field (N/kg)
- decreases as altitude increases
- varies according to location since Earth is not a perfect sphere
- on Earth g = 9.8 N/kg or 9.8 m/s^2

Gravitational Field Strength & Force of Gravity

*The gravitational field strength can be applied using the equation for Newton's second law of motion, **$F_g = mg$**, to determine the force of gravity acting on an object at Earth's surface.*

Force of Gravity

FORCE OF GRAVITY (F_g)

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

where F_g is the force of gravity acting on object (N)
m is the mass of the object (kg)
g is the gravitational field strength (N/kg)

NOTE!

F_g always acts downward.

Force of Gravity

PRACTICE

3. The average mass of a basketball is 0.63 kg. What is the force of gravity acting on the ball?

   F_g = 6.2 N[d]

Force of Gravity

PRACTICE

4. The force of gravity on a 250 kg spacecraft on the Moon's surface is 408 N[down].
   (a) What is the gravitational field strength on the Moon?

   (a) g = 1.6 N/kg[d]

Force of Gravity

PRACTICE

4. The force of gravity on a 250 kg spacecraft on the Moon's surface is 408 N[down].
   (b) What is the acceleration due to gravity of a free-falling object on the surface of the Moon?

   (b) g = 1.6 m/s^2[d]

Force of Gravity

PRACTICE

5. A 50 kg person is standing on a bathroom scale inside an elevator. The scale is calibrated in newtons. Use a FBD to help find the reading on the scale when the elevator is:
   (a) at rest.

   (a) F = 490 N

Force of Gravity

PRACTICE

5. A 50 kg person is standing on a bathroom scale inside an elevator. The scale is calibrated in newtons. Use a FBD to help find the reading on the scale when the elevator is:
   (b) moving up at a constant speed.

   (b) same as (a) b/c uniform motion

Force of Gravity

PRACTICE

5. A 50 kg person is standing on a bathroom scale inside an elevator. The scale is calibrated in newtons. Use a FBD to help find the reading on the scale when the elevator is:
   (c) is accelerating up at 2.2 m/s^2.

   (c) F = 600 N

Force of Gravity

PRACTICE

5. A 50 kg person is standing on a bathroom scale inside an elevator. The scale is calibrated in newtons. Use a FBD to help find the reading on the scale when the elevator is:
   (d) is accelerating down at 3.0 m/s^2.

   (d) F = 340 N

Gravitational Field Strength – Polar Ice Caps

The huge masses of major polar ice caps, such as the one covering much of Greenland, have a large gravitational attraction on nearby ocean waters. As polar ice caps melt due to global warming, their gravitational attraction decreases, so they are unable to keep as much water near them. Thus, sea levels farther from the melting ice caps will rise more than sea levels near the ice caps.

✔ Check Your Learning

WIKI (FORCES)

✎.... 3U2 - WS#2 (2nd Law - Vertical)