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The Value of g
Lesson Notes

Learning Outcomes
- What variables affect the gravitational field strength?
- How can the gravitational field strength be calculated?

Derivation of Gravitational Field Strength (g)
The equation for gravitational field strength can be derived from Newton's Universal Law of Gravitation and the class $F_{grav} = m \bullet g$ formula.

We know: $F_{grav} = m_{object} \bullet g$ and $F_{grav} = G \bullet \dfrac{m_{object} \bullet M_{Earth}}{d^2}$

So it must be true that: $\cancel{m_{object}} \bullet g = G \bullet \dfrac{\cancel{m_{object}} \bullet M_{Earth}}{d^2}$

Cancelling m_{object} yields: $\boxed{g = G \bullet \dfrac{M_{Earth}}{d^2}}$ $G = 6.6743 \times 10^{-11}\ N \bullet m^2/kg^2$

Location! Location! Location!
Derived through the use of the Law of Universal Gravitation, the fundamental equation for calculating the **gravitational field strength** (**g**) is …

$$g = G \bullet \frac{M_{planet}}{d^2}$$

$G = 6.6743 \times 10^{-11}\ N \bullet m^2/kg^2$

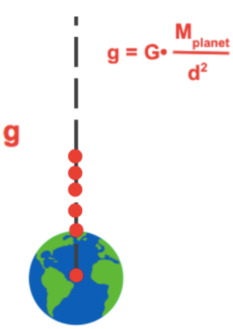
d = distance to the planet's center

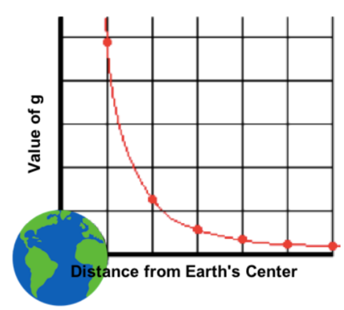
The value of **g** is location dependent!!
The variables that effect **g** are related solely to the gravitational environment where the object is located.
Object mass does **not** factor into the equation.

Height Matters
Let's use our equation to calculate g at various heights.

$d = R_{earth} + Height$

Location	d from Earth's center (m)	Value of g (m/s²)
Earth's surface	6.38×10^6 m	9.80
3000 km above surface	9.38×10^6 m	4.53
6000 km above surface	1.24×10^7 m	2.60
8000 km above surface	1.44×10^7 m	1.93
10000 km above surface	1.64×10^7 m	1.49
50000 km above surface	5.64×10^7 m	0.13





Out of This World

The equation for g is universal. So it can be used to calculate g on the surface of other planets if given their planet mass and planet radius.

Planet	Radius (m)	Mass (kg)	g (m/s^2)
Mercury	2.43×10^6	3.2×10^{23}	3.61
Venus	6.073×10^6	4.88×10^{24}	8.83
Mars	3.38×10^6	6.42×10^{23}	3.75
Jupiter	6.98×10^7	1.901×10^{27}	26.0
Saturn	5.82×10^7	5.68×10^{26}	11.2
Uranus	2.35×10^7	8.68×10^{25}	10.5
Neptune	2.27×10^7	1.03×10^{26}	13.3

Show your solutions to **Example Problem 1** and **Example Problem 2** on Slides 7 and 8.

Example Problem 1

Determine the value of g on the moon's surface given that …

$M_{moon} = 7.346 \times 10^{22}$ kg, $R_{moon} = 1.74 \times 10^6$ m

Example Problem 2

What is the value of g on the Space Shuttle when it is orbiting earth at an altitude of 500 km above its surface?

Given: $M_{earth} = 5.972 \times 10^{24}$ kg, $R_{earth} = 6.3781 \times 10^6$ m