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**MECHANICS**  
**SUB. CODE-BSPH1102**  
*For B.Sc.(Physics & Chemistry)*  
**(Gravitation and Central Force Motion)**

Newton's law of gravitation, Gravitational field

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# Gravitation

- Every object with mass attracts every other object with mass.
- Newton realized that the force of attraction between two massive objects:
  - Increases as the mass of the objects increases.
  - Decreases as the distance between the objects increases.



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# Law of Universal Gravitation

$$F_G = G \frac{M_1 M_2}{r^2}$$

G = Gravitational Constant

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

$M_1$  and  $M_2$  = the mass of two bodies

r = the distance between them



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# Law of Universal Gravitation

- The LoUG is an inverse-square law:
  - If the distance doubles, the force drops to  $1/4$ .
  - If the distance triples, the force drops to  $1/9$ .



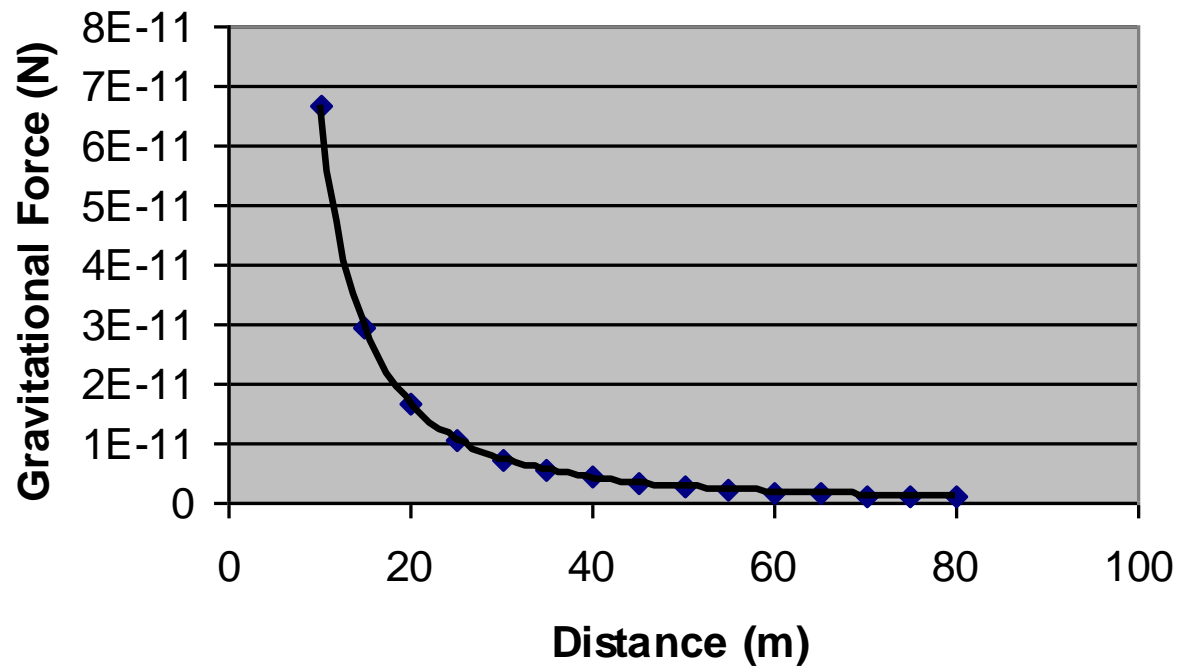
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# Law of Universal Gravitation

**M1 and M2 = 10 kg**





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# Law of Universal Gravitation

Jimmy is attracted to Betty. Jimmy's mass is 90.0 kg and Betty's mass is 57.0 kg. If Jim is standing 10.0 meters away from Betty, what is the gravitational force between them?

$$F_G = GM_1M_2 / r^2$$

$$F_G = (6.67 \times 10^{-11} \text{ Nm}^2/\text{kg}^2)(90.0 \text{ kg})(57.0 \text{ kg}) / (10.0 \text{ m})^2$$

$$F_G = (3.42 \times 10^{-7} \text{ Nm}^2) / (100. \text{ m}^2)$$

$$F_G = 3.42 \times 10^{-9} \text{ N} = 3.42 \text{ nN}$$

In standard terms, that's 7.6 ten-billionths of a pound of force.



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# Law of Universal Gravitation

The Moon is attracted to the Earth. The mass of the Earth is  $6.0 \times 10^{24}$  kg and the mass of the Moon is  $7.4 \times 10^{22}$  kg. If the Earth and Moon are 345,000 km apart, what is the gravitational force between them?

$$F_G = GM_1M_2 / r^2$$

$$F_G = (6.67 \times 10^{-11} \text{ Nm}^2/\text{kg}^2)$$

$$F_G = 2.49 \times 10^{20} \text{ N} \frac{(6.0 \times 10^{24} \text{ kg})(7.4 \times 10^{22} \text{ kg})}{(3.45 \times 10^8 \text{ m})^2}$$



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# Gravitational Field

Gravitational field – an area of influence surrounding a massive body.

Field strength = acceleration due to gravity ( $g$ ).

$$g = GM / r^2$$

Notice that field strength does not depend on the mass of a second object.

$$GM_1M_2/r^2 = M_2g = F_G = F_w$$

So gravity causes mass to have weight.





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# Reference

**Mechanics** by *D. S. Mathur*, S. Chand, chp-12.2, 12.7

