

Newton's law of gravitation:

$$F = G m_1 m_2 / r^2$$

To compare the gravitational force exerted on a baby by Jupiter and by the baby's mother when the baby is held close to the mother's chest, consider the ratio of forces. The baby's mass cancels:

$$F_J / F_M = (M_J / r_J^2) / (M_M / r_M^2) = (M_J / M_M)(r_M / r_J)^2$$

Assumed values:

Mother's mass:  $M_M = 65 \text{ kg}$

Baby's mass:  $m_b = 3.5 \text{ kg}$

Center-to-center distance (mother holding baby close):  $r_M = 0.20 \text{ m}$

Jupiter's mass:  $M_J = 1.898 \times 10^{27} \text{ kg}$

Earth–Jupiter distance:

Closest approach:  $r_J = 6.28 \times 10^{11} \text{ m}$

Farthest separation:  $r_J = 9.28 \times 10^{11} \text{ m}$

Mother–baby gravitational force:

$$F_M = G (65)(3.5) / (0.20)^2$$

$$F_M \approx 3.8 \times 10^{-7} \text{ N}$$

Jupiter–baby gravitational force:

Closest approach:

$$F_J = G (1.898 \times 10^{27})(3.5) / (6.28 \times 10^{11})^2$$

$$F_J \approx 1.1 \times 10^{-6} \text{ N}$$

Farthest separation:

$$F_J \approx 5.2 \times 10^{-7} \text{ N}$$

Force comparison:

Closest approach:

$$F_J / F_M \approx (1.1 \times 10^{-6}) / (3.8 \times 10^{-7}) \approx 2.9$$

Farthest separation:

$$F_J / F_M \approx (5.2 \times 10^{-7}) / (3.8 \times 10^{-7}) \approx 1.4$$

The numerical result depends strongly on the assumed center-to-center distance because of the inverse-square dependence on  $r$ .