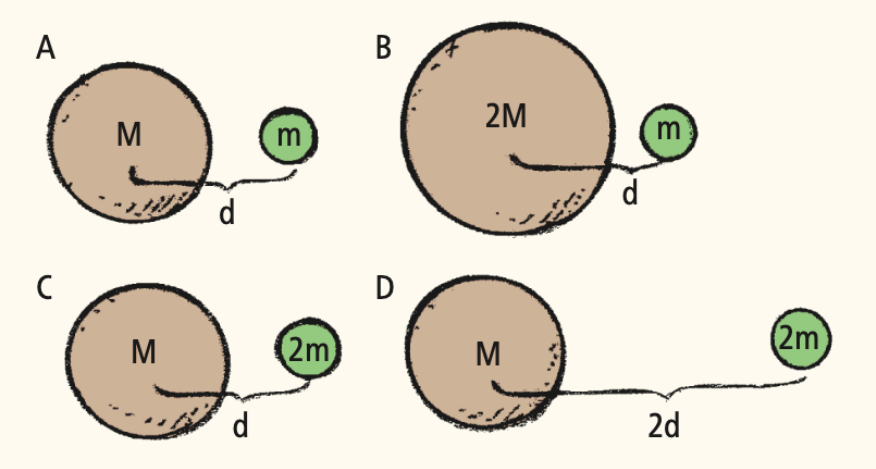
Ch. 9 HW Gravity

Show **ALL WORK**. You may be randomly selected to solve one of the problems next class which will count towards 20% of your final grade.

1) **(5 pts)** The planet and its moon gravitationally attract each other. For each of the figures, **calculate** the force of attraction between each pair and rank them from greater to least.



_____ _____ _____ _____

greatest least

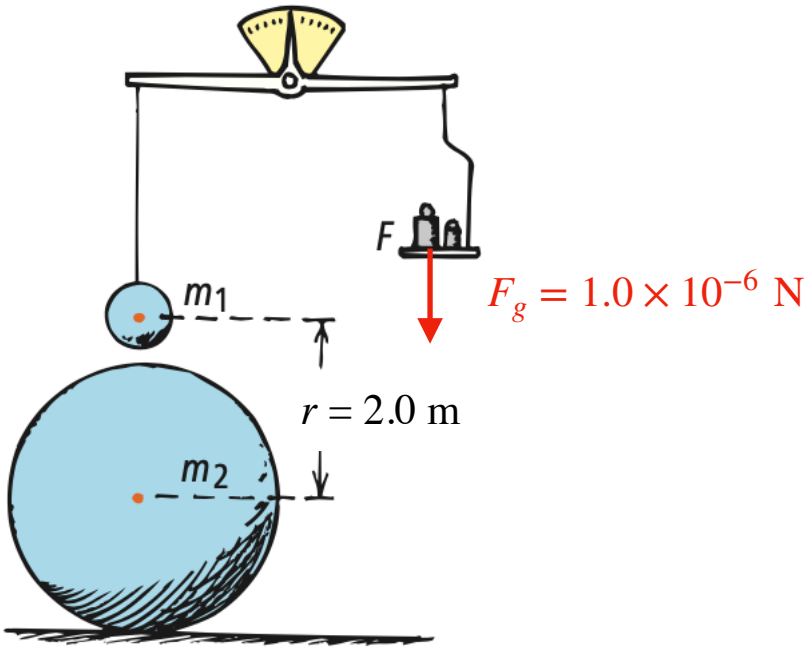
2) **(3 pts)** If the weight of a body on Earth's surface is W_E then rank its weight on

(a) **(1 pt)** The Moon compared to Earth

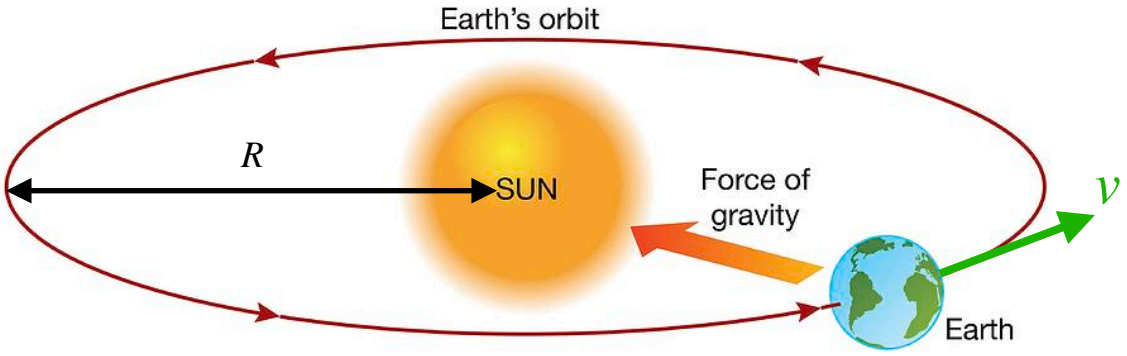
(b) **(1 pt)** Mars compared to Earth

(c) **(1 pt)** Jupiter compared to Earth

3) **(5 pts)** In Jolly's method for measuring G using a torsion balance, the spheres with masses $m_1 = 10$ kg, and $m_2 = 6$ tons (of lead) attract each other with a force F_g which was measured by providing the weights (rights) needed to restore balance. Based on this measurement, calculate the value of the universal constant, G. (Round to 3 significant figures, and write units)



4) **(15 pts)** Earth orbits the sun with due to a gravitational pull that the sun exerts on Earth, $F_g = GM_E M_\odot / R^2$.



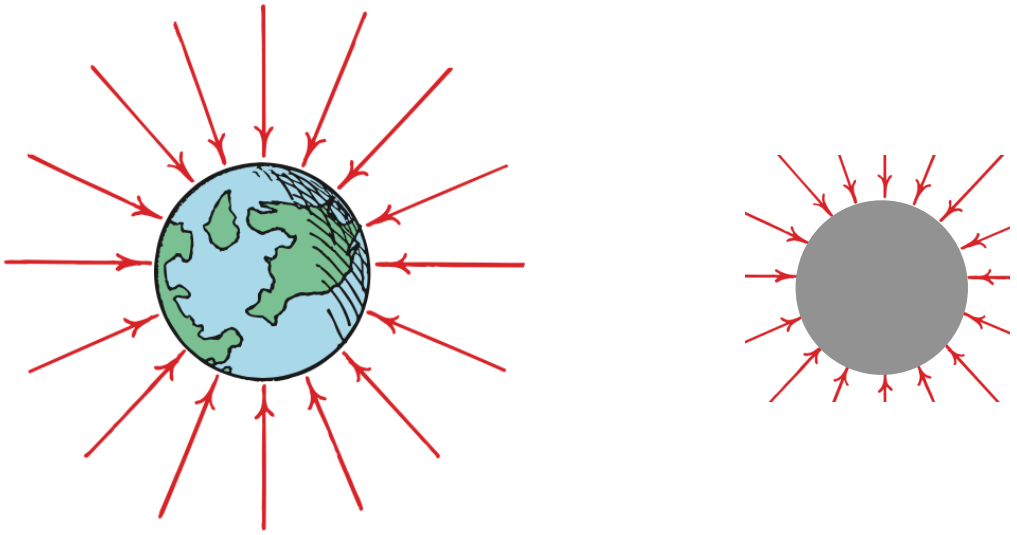
By how much would the gravitational pull from the Sun to Earth change if:

(a) **(5 pts)** distance between the Sun and Earth *doubled* ?

(b) **(5 pts)** the Sun's mass increases by *3 times* its original value.

(c) **(5 pts)** if the Sun were to disappear what would the the gravitational force ? what path would the Earth follow ? Draw the path (in the figure) you think Earth would follow in this case.

5) **(15 pts)** The gravitational field vectors of the Earth and Moon are shown side by side. (Use numerical values provided in the formula sheet)

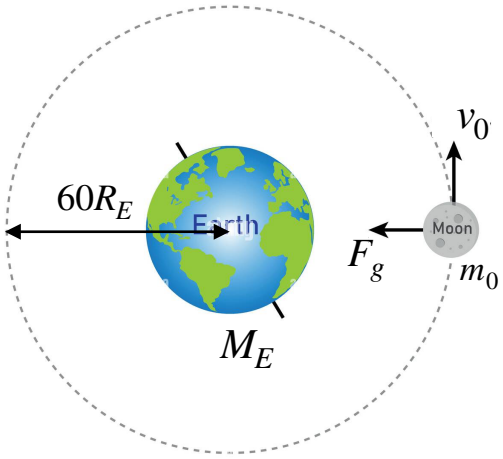


(a) **(5 pts)** Calculate the gravitational field the Earth produces at its surface

(b) **(5 pts)** Calculate the gravitational field the Moon produces at its surface

(c) **(5 pts)** How much heavier do we feel on Earth compared to the Moon ? (*hint*: take the ratio of the Earth to Moon's gravity fields.)

6) **(10 pts)** The Moon (Earth's only natural satellite) has a mass m_0 and orbits the Earth at a distance of approximately 60 times the Earth's radius (*image not to scale*) with a tangential velocity of v_0



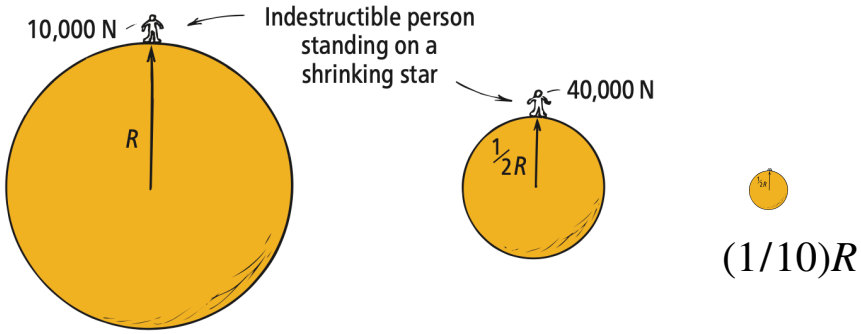
(a) **(5 pts)** write a general expression for the gravitational force F_g the Earth exerts on the Moon in terms of the specified masses (M_E, m_0) and Earth's radius R_E

(b) **(5 pts)** write a general expression for Earth's *gravitational field* at: (*hint:* recall, the field due to a mass M is $g_{\text{field}} = F_g/m$)

(i) Earth's *surface*

(ii) the Moon's orbit

7) **(10 pts)** Suppose you were indestructible and could travel in a spaceship to the surface of a star and found that you weight 10,000 N. At some point, the start burns and collapses to a small and even smaller radius, but its mass remains the same throughout this process.



(a) **(5 pts)** If the star collapses to *half* or (1/2 *R)* its original radius, would you weight more or less than before ? Calculate how much you would you weight at the surface of the collapsed star.

(b) **(5 pts)** If the start further shrinks to a size of one tenth (1/10 *R*) of its original radius, how much would you weight in this case ?

8) **(15 pts)** Suppose our Sun runs out of fuel and collapses to a radius of about 2950 meters and suppose you (100 kg person) were at its surface.

(a) **(5 pts)** How much force would you experience in this case ? (*hint*: the Sun's mass remains unchanged during the collapse)

(b) **(5 pts)** The escape velocity of an object refers to the minimum velocity required to escape the gravitational pull of a very massive object, and for the case of the sun, it is given by

$$v_{\text{escape}} = \sqrt{2GM_{\odot}/R_{\odot}},$$

Calculate the escape velocity (in m/s) of an object near the Sun's surface after it collapses to a radius of 2950 m (with Sun's mass kept constant).

(c) **(5 pts)** The speed of light in vacuum is approximately $c = 2.997 \times 10^8$ m/s. Compare your result in part (b) to the speed of light. Does it exceed the speed of light ? If so, would light be able to escape the gravitational pull of the Sun in this case ? (In this hypothetical scenario, the Sun has become a Black Hole, where not even light can escape from its strong gravitational pull)