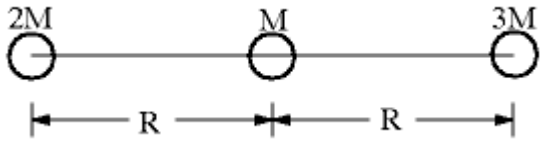
PROBLEM 1 – 10 points

[6 points] (a) Three masses, of mass 2*M*, *M*, and 3*M* are equally spaced along a line, as shown. The only forces each mass experiences are the forces of gravity from the other two masses.



[3 points] (i)Which mass experiences the largest magnitude net force?

[ ] mass 2*M* [ ] mass *M* [ ] mass 3*M* [ ] equal for all three
[ ] the 2*M* and 3*M* masses have equal magnitude net forces larger than that of mass *M*

Justify your answer:

[3 points] (ii) What is the magnitude of the net force experienced by the object of mass 2*M*?

[ ] $GM^2/2R^2$ [ ] $2GM^2/R^2$ [ ] $3GM^2/R^2$ [ ] $7GM^2/2R^2$ [ ] $8GM^2/R^2$

Justify your answer:

[4 points] (iii) Which of the following changes would cause the magnitude of the force experienced by the 2*M* object to increase by a factor of 4? **Select all that apply.**

[ ] double the mass of all three objects

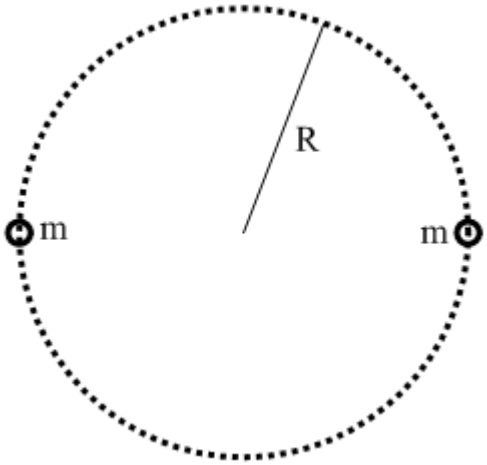
[ ] change the mass of the 2*M* object to 8*M*, without changing the mass of the other objects

[ ] double *R*

[ ] Move the system to a parallel universe where the value of the universal gravitational constant is four times larger than its value in our universe

PROBLEM 2 – 10 points

A binary star system consists of two identical stars traveling in circular orbits of radius *R* around their center-of-mass. Each star travels at a constant speed *v*.



[7 points] (a) What is *m*, the mass of one of the stars? Express your answer in terms of *R*, *v*, and the universal gravitational constant *G*.

[3 points] (b) How much work does one star do on the other over half of an orbit?

PROBLEM 3 – 15 points

[8 points] (a) A ball of mass m is placed on the x-axis at $x = 0$. A second ball of mass $2m$ is placed on the x-axis at $x = -a$. A third ball, with a mass of m, is placed on the x-axis at an unknown location. If the net gravitational force exerted on the ball at the origin due to the other two balls has a magnitude of $\frac{6Gm^2}{a^2}$, what is the location of the third ball? Find all possible solutions.

[3 points] (b) What is the numerical value of the escape speed for the Moon? In other words, with what speed does a projectile have to be launched from the surface of the Moon to escape from the Moon's gravity? The Moon's mass is $M = 7.35 \times 10^{22}$ kg and its radius is $R = 1.74 \times 10^{6}$ m.

[4 points] (c) If a projectile is launched straight up from the surface of the Moon with 90% of the escape speed, what is the maximum distance it gets from the surface of the Moon before turning around? Assume the Moon is the only object influencing the projectile after launch.