Useful Equations

✔ Newton's Law of Gravitation: \( \vec{F}_g = G \frac{m_1 m_2}{r^2} (-\hat{r}) \)

◦ Gravitational Constant: \( G = 6.67 \times 10^{-11} \text{ N m}^2/\text{kg}^2 \)

✔ Gravitational Potential Energy: \( U = -\frac{G m_1 m_2}{r} \)

Problems:

1. (***) If we can assume that a planet (of mass \( M_p \)) travels in a circular orbit about the sun (which has a mass \( M_S \)) at a radius \( r \), how long is one year for the planet? (i.e. how long does it take to make one revolution? If the Earth is \( 1.49598 \times 10^{11} \text{ m} \) from the sun, and the sun has a mass \( M_S = 1.98895 \times 10^{30} \text{ kg} \) and the earth has a mass \( M_p = 5.97420 \times 10^{24} \text{ kg} \), how long is one year on Earth?

2. (***) Satellites are often put into a geosynchronous orbit, so that they do not appear to move in the sky. If the altitude at which these satellites rest is \( h \), at what speed do they need to move so that they do not appear to move relative to the ground? (Call the mass of the earth \( M_E \) and the radius of the earth \( R_E \))
3. (**) Determine the minimum velocity required for an object of mass $m$ to escape the gravitational pull of a larger object of mass $M$ if the initial distance between the two objects is $R$. (There is an easier way to do this than you saw in lecture – just use conservation of energy)

4. (***) Two objects, $m_1$ and $m_2$ are separated by a distance $d$. At what position could I place a third mass ($m$) so that it felt no NET gravitational force? Check your answer by using the case that $m_1 = m_2$. (Comment: If you get to a point where you need to use the quadratic formula – tell me and I'll show you a neat trick)