The formats (type, length, scope) of these Prep problems have been purposely created to closely parallel those of a typical exam (indeed, these problems have been taken from past exams). To get an idea of how best to approach various problem types (there are three basic types), refer to these sample problems.
1. a. “The gravitational force between two masses is inversely proportional to the __________ between their __________.

b. T/F/N? (Explain, as always.) While standing here on earth, you exert a gravitational force on the moon.

c. Express \( G \) in fundamental (“base”) SI units: kg, m, s.

d. The earth’s radius is \( 6.37 \times 10^6 \) m. Show with a calculation that the earth’s mass is \( 5.98 \times 10^{24} \) kg.

2. a. A 2300-kg satellite is orbiting the earth at an altitude equal to twice the earth’s radius.

   (i) Find the satellite’s weight at that altitude.

   (ii) Find the gravitational force exerted by the earth on the satellite at that altitude.

b. (i) What is the local \( g \) value at an earth altitude of 250 km (about where the Space Shuttle often orbits)?

   (ii) What is the speed of the Space Shuttle’s orbit at an altitude of 250 km?

   (ii) At what earth altitude is the local \( g \) value 90% of earth’s surface \( g \) value?

   (iv) What is the speed of a satellite orbiting earth where local \( g \) is 10% of earth’s surface \( g \)?

c. A certain planet (not Earth) has a radius of \( 5.59 \times 10^6 \) m. A satellite that orbits this planet at an altitude of 490 km will complete a revolution every 170 minutes. What is the value of \( g \) on the surface of this planet?
3. a. You have landed on the surface of a newly-discovered planet (which is spherical and without mountains or craters), and you have made the following observations:
   - A rock dropped from rest from a height of 2.00 m above the surface takes 0.987 s to reach the surface.
   - A trip by land rover around the equator of this planet covered a distance of 13,500 km.
   - The planet has a small moon that orbits the planet once every 416 hours.
   At what altitude does that moon orbit above the surface of the planet?

   b. Two identical planets, each of mass $m$, move in a circular orbit (of radius $r$) diametrically opposite to each other around a star of mass $M$, as shown here. Find an expression (in terms of $m$, $r$, $M$ and $G$) for their orbital period, $T$.

   c. Three stars of equal mass $m$ move in identical circular orbits around their common center-of-mass point. As shown here, each star’s center is located at one corner of an equilateral triangle with a side of length $L$. Find the speed $v$ of each star, expressed in terms of $m$, $L$ and $G$. Assume that gravity is the only force acting on the stars and that there are no objects other than those stars.
4. a. A certain planet has twice the mass of earth but just 1/4 the value of earth’s g at its surface.
   (i) Find the planet’s radius.

   (ii) Find the escape speed from this planet.

b. Find the total gravitational potential energy of the three-mass system shown here.

5. a. The 75,000-kg Space Shuttle needs to boost itself from its current orbit (altitude 250 km) to the orbit of the Hubble Space Telescope (altitude 610 km). How much energy does this boost require?

b. A 20 kg satellite has a circular orbit (\(T = 2:24:00; C = 5.00 \times 10^7 \text{ m}\)) around an unknown planet.
   (i) Find the speed of the satellite in its circular orbit.
   (ii) Find the radial acceleration of the satellite.
   (iii) Find the mass of the planet.
   (iv) Local \(g\) on the surface of the planet is found to be 8.00 m/s\(^2\). Find the radius of the planet.
   (v) At what minimal radial speed (directly away from the planet [actually, it could be any direction, so long as the satellite doesn’t collide with the planet]) would the satellite need to be moving in order to escape from the planet’s gravitational field?
6. a. An object of mass $m$ is dropped [from rest] from height $h$ above a planet of mass $M$ and radius $R$. Find an expression for the object’s impact speed.

b. What is the energy cost (expressed in Joules per kg) to boost a satellite from the earth’s surface into geosynchronous orbit? [Ignore the rotation of the earth—see the notes on problems 2d and 4a.]

c. A 22.0 kg satellite is in a steady, circular orbit around the earth at an altitude where local $g = 8.00 \text{ m/s}^2$. How much energy would be required to move that satellite to another steady, circular orbit with a period that is twice as long as its current period?
6. d. A satellite \((m = 1000 \text{ kg})\) is in a geosynchronous orbit around the earth so that it remains directly above the same location on the earth’s equator.

*Note: For this problem, you may either use the numeric values provided—and then solve for numeric answers—or you may provide solutions in symbolic form, in which case you may assume that the following values are known: \(m, G, m_{\text{earth}}, R_{\text{earth}}\). And if you do choose to use symbols, you do not even need to do the algebra. Instead, you can just show the necessary equations and describe the order in which someone would solve for the required answer.*

(i) How much work must be done on the satellite so that it can leave its current orbit and escape earth orbit altogether?

(ii) What is the value of “local \(g\)” at the satellite’s altitude?
(iii) If you were to release a brick from rest from the satellite’s altitude, at what altitude would the brick attain a speed equal to half that of the orbiting satellite? You may ignore air resistance, if any.