Quiz 6

Solutions

Choose the best answer.

1. There is a point on the line between the earth and the moon where the combined gravitational field of those two bodies is zero. As a spacecraft (coasting and influenced only by gravity) passes through that point on its way to the moon, what change occurs in the weight of an astronaut, as measured by a scale in the spacecraft?

   A. It changes from a small amount toward the earth to a small amount toward the moon, passing through zero in between..

   B. It remains at the value it had when the astronaut was on earth.

   ☛ C. It does not change because it is always zero. [Weightless as long as the only force acting is gravity.]

   D. None of the above is true.

Choose T or F depending on whether the statement is true or false.

2. When the positions of the sun, moon and earth are all on the same line the ocean tides are especially large. **T** {Spring tides]

3. A satellite of mass m is to be put into a circular orbit of radius $a = \frac{5}{4}R$ around the earth, where R is the earth's radius. It is launched vertically from earth's surface by a booster rocket. At distance $a_1 = \frac{10}{9}R$ (from earth's center), the booster is disconnected and falls back to earth. The satellite continues to rise without power from its engine until it reaches distance a, where it is momentarily at rest. At that point its engine is fired horizontally to give it the energy of the orbit.

   a. How much energy does its engine provide to put it in the final orbit? [What is its total energy just before the engine is fired?]

   b. What is its kinetic energy at the moment when the booster is disconnected?

   c. How much energy did the booster provide to the satellite during the first part of its flight?

   [All answers in terms of G, earth's mass M, R, and m.]

a. Just before the engine is fired, the satellite is at rest, so its total energy is $E_1 = -\frac{GMm}{a} = -\frac{4}{5}\frac{GMm}{R}$. The total energy of the orbit is $E_2 = -\frac{GMm}{2a} = -\frac{2}{5}\frac{GMm}{R}$. The engine supplies energy $E_2 - E_1 = \frac{2}{5}\frac{GMm}{R}$.

b. The total energy at that point is also E_1, but the potential energy is $U = -\frac{GMm}{a_1} = -\frac{9}{10}\frac{GMm}{R}$, so the kinetic energy is $K = E_1 - U = \frac{1}{10}\frac{GMm}{R}$.

c. Before launch, the total energy of the satellite was $E_0 = -\frac{GMm}{R}$, so the booster supplied energy $E_1 - E_0 = \frac{1}{5}\frac{GMm}{R}$.