AP Physics 1 Course

Compiled and Lectured by
Chunlai Yang
Ph.D. in Physics

Handout of Class 10

Chapter 6, Newton's Law of Gravitation

1. The formula
   $F_G = Gm_1m_2/r^2$
   - $G = 6.67\times10^{-11}$, how to find the unit?

   G is very small, so don't consider the gravitational force between two small blocks
   - Only consider the gravity by earth
2. The relation with F = mg
   From $F_G = Gm_1m_2/r^2$ and F = ma, get the formula for acceleration g:
   $g = GM/r^2$
   - where for earth: $R = 6.37\times10^6$ m; $M = 5.98\times10^{24}$ kg
   - then at the surface of the earth: $g = 9.8$ m/s^2

   When h is small, F_G doesn't change much at different height - constant g, so:
   - F = mg is only correct near the earth surface
3. The potential energy
   $W_G = -\Delta U$
   - F_G is a conservative force
   - integration of F_G over r, get U_G formula:

   $U_G = -GmM/r$
   - mgh for gravitational potential energy is only correct near the earth surface
   - Can't mix using the above two formulas (0 potential location)
4. Apply to Satellite
   Far from the earth, so have to use: $F_G = GmM/r^2$
   F_G will serve as the centripetal force
   The r is the center-to-center distance
   - altitude is center-to-surface distance

   The equations for the satellite motion:
   $GmM/r^2 = mv^2/r$
   The energy of the satellite:
   For a circular orbit which M is at rest:
   $E = K + U = -GmM/(2r)$

- $K = 1/2mv^2 = GmM/2r = ½|U|$
- $E = K + U = 1/2mv^2 - GmM/r$
- $E = -GmM/(2r) = -K$

Its total energy is "-", can't escape to the space

- What is the escape speed ($v_{esc} = 1.12\times10^4$ m/s)

5. The communication satellite

   Geo-synchronous – the same period, apply the right formula for the a_c

   Kepler's 3rd Law: $R^3/T^2 = const$

   - How high does a GPS satellite locate above the earth surface?

   ($T = 86400$ s; $r = 4.23\times10^7$ m; $h = 3.59\times10^7$ m)

   The periods: days, month, years

   - The most familiar lunar cycle, defined as the time interval between two consecutive occurrences of a particular phase (such as new moon or full moon). The mean length of the synodic month is 29.53059 days (29 days, 12 hours, 44 minutes, 2.8 seconds)
   - Tropical year is the time taken for the tilt of the earth's axis to come back to the same angle relative to the sun. (365.242 days)

   What is angular velocity of earth self rotate? When you sit at home: how fast are you moving with earth together and how far do you travel each day?

   ($\omega = 0.0000727$ rad/s; $v = 463$ m/s; $d = 40000$ km)

6. The angular momentum of satellite

   There is no torque for the satellite

   Apply the conservation of angular momentum on ellipse

   - Kepler's 2nd Laws

7. Kepler's Three Laws

   1st, the ellipse

   - the solution of the equation

   2nd: sweeping the same area in the same time

   - angular momentum conservation on the ellipse orbit

   3rd, $R^3/T^2 = const.$

   - gravity as the centripetal force

8. The tides

   Mainly due to the gravity from moon: twice a day by earth self rotation

   When the sun and moon are in the line:

   - A spring tide, during new and full moon
   - A neap tide, seven days after a spring tide

The Princeton Review AP Physics 1 Prep (11th Premium Edition)

The homework: Chapter Circular Motion and Gravitations: MC: 5 – 12; FR: 1, 2

Chapter Energy: MC: 5

Please submit your homework to goEducationInstitute@gmail.com

After finish the homework, please do the quiz and submit by Google Form