I. Free falling objects and the equations to calculate velocity and distance
   A. The acceleration due to gravity is (on average) 9.81 m/s^2
      1. Round to 10 m/s^2 in classroom discussions, examples, homework
      2. The more precise number is used in lab
      3. Variables in equations
         a. ***a*** is used to represent acceleration in equations
         b. ***g*** is used in equations to represent the acceleration of gravity acting on falling objects
   B. How fast is the object going after a certain amount of time that if falls
      1. gains speed for each second it falls—10 m/s for each second
      2. calculate how fast by the equation $v = gt$
      3. this is its *instantaneous* velocity, not its average velocity
      4. objects tossed upward slow down at this acceleration too
II. Projectile motion
   A. involves objects moving along curved paths
      1. horizontal movement are constant velocity motions
      2. vertical movements are accelerated motions
      3. independent of one another
   B. object projected by some means that continues in motion under influence of gravity. Separate investigation of horizontal and vertical motion
      1. horizontal neglecting friction,
         a. no change in velocity
         b. equal distances in equal times
         c. no acceleration
      2. vertical like freely falling objects,
         a. accelerate due to gravity
         b. velocity changes
         c. falls farther during each successive time interval
      3. each component act independently of one another
   C. ball rolling forward and continues off the tabletop
      1. see ball from top—
         a. horizontal movement
         b. not affected by vertical l movement
         c. does not affect vertical movement
      2. see ball from front—
         a. vertical movement
         b. not affected by horizontal movement
         c. does not affect horizontal movement
   D. projectile moving upward initially, in addition to forward
      1. without gravity or friction
         a. it would continue upward diagonally
         b. we will ignore friction
      2. gravity acts vertically, independent of horizontal velocity
         a. falling from the ‘no gravity’ path
         b. just as far as if it had been dropped from the ‘no gravity’ path at the instant it was launched upward in the gravity environment

3. no acceleration in horizontal direction after it is fired
    a. moves equal distance forward for each time interval
    b. there is no forward acceleration, only speed
4. the vectors of horizontal and vertical velocity represent these

III. Projectile examples
- A. Cannonball
  1. without gravity
  2. gravity is external force
     a. horizontal acceleration is zero—no change in speed
     b. vertical acceleration is ~$10 m/s^2$
- B. airplane and package problem
  1. 40 m/s forward velocity of plane and package
  2. falls to directly below the plane
- C. cannonball shot at angle
  1. path diagonal without gravity
  2. path parabola with gravity
- D. Monkey and zookeeper animations
  1. Without gravity—straight to him
  2. With gravity—fast shot
  3. With gravity—slower shot
- E. calculate how fast cannon ball is going in vertical and horizontal direction
  1. horizontal speed constant
  2. vertical speed varies with time
  3. overall speed calculated with vectors of each, added together

IV. Projectile Range
- A. Steepness affects how long it is in the air
  1. complementary angles have same range
  2. greatest range at 45^o angle
- B. vertical speed is zero at top of trajectory
- C. consider air resistance

V. Calculations of speed
- A. Baseball from 5 m platform
  1. know height and distance of throw
  2. know vertical $d=(1/2)gt^2$, g, and d
  3. find t to fall
  4. divide horizontal distance by t
- B. Curvature of Earth= 5 m vertical for each 8000 m horizontal
  1. if you could throw 8000 m/s, ball would never reach the ground
  2. same principle for orbiting objects

VI. Rotational speed
- A. Directly proportional to distance from center of rotation
- B. Cones roll in circles
  1. smaller diameter goes slower, less distance in one rotation
  2. greater diameter goes faster, further in one rotation
  3. this is why train wheels are made like they are