Academic Year 2020-21

Tutorial #01

PH100: Mechanics and Thermodynamics

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1. Consider two points located at $\boldsymbol{r_1}$ and $\boldsymbol{r_2}$, separated by distance r = | $\mathbf{r_1}$ — $\mathbf{r_2}$|. Find a vector $\boldsymbol{A}$ from the origin to a point on the line between $\boldsymbol{r_1}$ and $\boldsymbol{r_2}$ at distance $x\ r$ from the point at $\boldsymbol{r_1}$, where x is some number.

2. At $t = 0$, an elevator departs from the ground with uniform speed. At time T_1 a boy drops a marble through the floor. The marble falls with uniform acceleration $g = 9.8\ m/s^2$, and hits the ground T_2 seconds later. Find the height of the elevator at time T_1.

3. By relative velocity we mean velocity with respect to a specified coordinate system. (The term velocity, alone, is understood to be relative to the observer's coordinate system.)

   (a) A point is observed to have velocity V_A relative to coordinate system A. What is its velocity relative to coordinate system B, which is displaced from system A by distance R? (R can change in time.)

   (b) Particles a and b move in opposite directions around a circle with angular speed \omega. At $t = 0$ they are both at the point $r = l\ \boldsymbol{j}$, where l is the radius of the circle. Find the velocity of a relative to b.

4. The rate of change of acceleration is sometimes known as "jerk." Find the direction and magnitude of jerk for a particle moving in a circle of radius R at angular velocity \omega. Draw a vector diagram showing the instantaneous position, velocity, acceleration, and jerk.

5. A particle moves in a plane with constant radial velocity $4\ m/s$. The angular velocity is constant and has magnitude 2 rad/s. When the particle is $3\ m$ from the origin, find the magnitude of (a) the velocity and (b) the acceleration.

6. A particle moves outward along a spiral. Its trajectory is given by $r = A\ \theta$, where A is a constant. $A = (1/\pi)\ m/rad$. θ increases in time according to $\theta = k\ t^2\ /2$, where k is a constant.
   (a). Sketch the motion, and indicate the approximate velocity and acceleration at a few points.
   (b). Show that when the radial acceleration is zero. At what angles do the radial and tangential accelerations have equal magnitude?