HW # 1: Kinematics of Particle

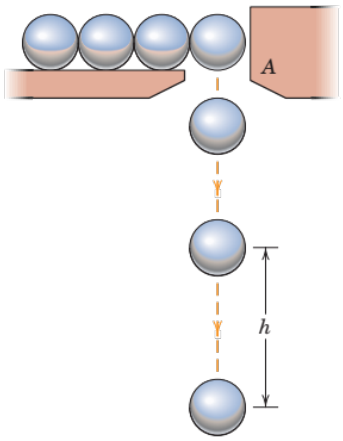

Figure 1

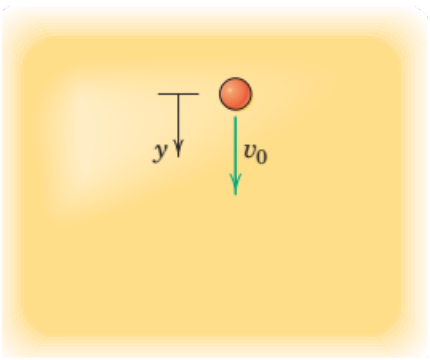

Figure 2

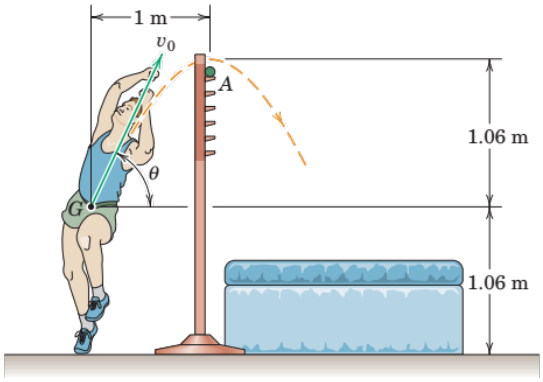

Figure 3

Q1: Small steel balls fall from rest through the opening at *A* at the steady rate of 2 per second as shown in Figure 1. Find the vertical separation *h* of two consecutive balls when the lower one has dropped 3 metres. Neglect air resistance.

Q2. A projectile is fired downward with initial speed v_0 in an experimental fluid (see Figure 2) and experiences an acceleration $a = \sigma - \eta v^2$, where σ and η are positive constants and v is the projectile speed. Determine the distance traveled by the projectile when its speed has been reduced to one-half of the initial speed v_0. Also, determine the terminal velocity of the projectile.

Q3. The center of mass *G* of a high jumper follows the trajectory shown in Figure 3. Determine the component v_0, measured in the vertical plane of the figure, of his takeoff velocity and angle θ if the apex of the trajectory just clears the bar at *A*.

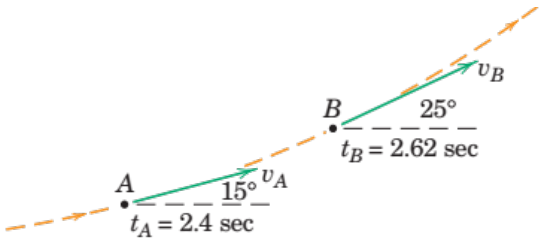

Figure 4

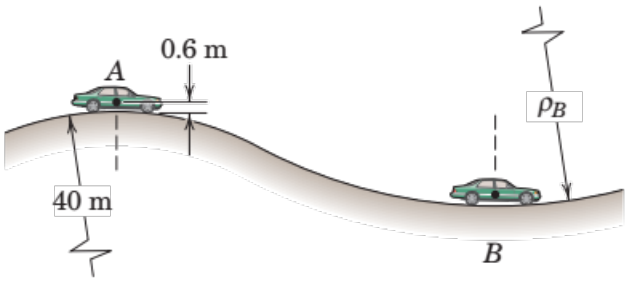

Figure 5

Q4. A particle moves along the curved path as shown in Figure 4. The particle has a speed $v_A = 4$ m/sec at time t_A and a speed $v_B = 4.2$ m/sec at time t_B. Determine the average values of the normal and tangential accelerations of the particle between points *A* and *B*.

Q5. The speed of a car increases uniformly with time from 50 km/h at *A* to 100 km/h at *B* during 10 seconds (See Figure 5). The radius of curvature of the hump at *A* is 40 m. If the magnitude of the total acceleration of the mass center of the car is the same at *B* as at *A*, compute the radius of curvature ρ_B of the dip in the road at *B*. The mass center of the car is 0.6 m from the road.

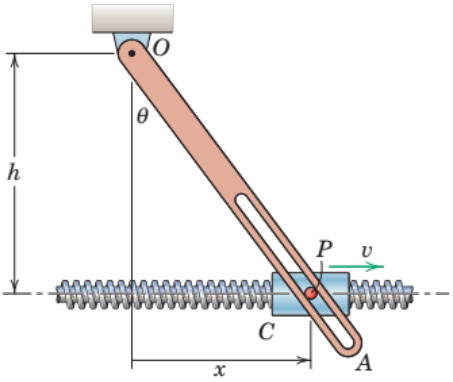

Figure 6

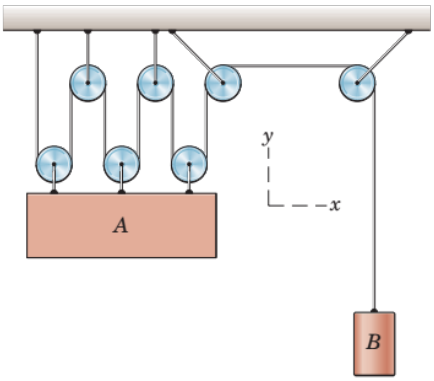

Figure 7

Q6. Rotation of bar *OA* is controlled by the lead screw which imparts a horizontal velocity v to collar *C* and causes pin *P* to travel along the smooth slot as seen in Figure 6. Determine the values of dr/dt and $d\theta/dt$, where $r = \overline{\text{OP}}$, if $h = 160$ mm, $x = 120$ mm, and $v = 25$ mm/s at the instant represented.

Q7. At the instant represented, $v_{B/A} = 3.5\,\mathbf{j}$ m/s for the system shown in Figure 7. Determine the velocity of each body at this instant. Assume that the upper surface of *A* remains horizontal.