PROBLEMS
(RECTILINEAR MOTION)
1. A ball is thrown vertically upward with an initial speed of 25 m/s from the base A of a 15-m cliff. Determine the distance $h$ by which the ball clears the top of the cliff and the time $t$ after release for the ball to land at B. Also, calculate the impact velocity $v_B$. Neglect air resistance and the small horizontal motion of the ball.
2. A motorcycle patrolman starts from rest at A two seconds after a car, speeding at the constant rate of 120 km/h, passes point A. If the patrolman accelerates at the rate of 6 m/s\(^2\) until he reaches his maximum permissible speed of 150 km/h, which he maintains, calculate the distance s from point A to the point at which he overtakes the car.
3. The body falling with speed strikes $v_o$ and maintains contact with the platform supported by a nest of springs. The acceleration of the body after impact is $a = g - cy$ where $c$ is a positive constant and $y$ is measured from the original platform position. If the maximum compression of the springs is observed to be $y_m$, determine the constant $c$. 
4. A test projectile is fired horizontally into a viscous liquid with a velocity \( v_0 \). The retarding force is proportional to the square of the velocity, so that the acceleration becomes \( a = -kv^2 \). Derive expressions for the distance \( D \) traveled in the liquid and the corresponding time \( t \) required to reduce the velocity to \( v_0/2 \). Neglect any vertical motion.
5. The preliminary design for a rapid-transit system calls for the train velocity to vary with time as shown in the plot as the train runs the 3.2 km between stations A and B. The slopes of the cubic transition curves (which are of form \( a+bt+ct^2+dt^3 \)) are zero at the end points. Determine the total run time \( t \) between the stations and the maximum acceleration.
6. The brake mechanism shown in the figure is composed of a piston moving in a fixed cylinder filled with oil. When the brake pedal is pressed while the vehicle moves with a speed \( v_0 \), the piston moves, oil passes through the channels inside the piston and the vehicle slows down in proportion to its speed, \( a = -kv \). Determine a) \( v \) in terms of \( t \), b) \( x \) in terms of \( t \), c) \( v \) in terms of \( x \). Also construct the related graphics.
7. A particle moves along the y axis with an acceleration given by \( a(t)=5\sin \omega t \text{ cm/s}^2 \) where \( \omega=0.7 \text{ rad/s} \). Initially when \( t=0 \), the particle is 2 cm above the origin and is moving downward with a speed of 5 cm/s.

a) Determine the velocity and position of the particle as functions of time.

b) Show the position, velocity and acceleration on a graph for the interval of \( t=0 \) and \( t=4 \text{ s} \).

c) Determine the displacement \( d \) of the particle between \( t=0 \) and \( t=4 \text{ s} \).

d) Determine the total distance \( s \) traveled by the particle between \( t=0 \) and \( t=4 \text{ s} \).