The position coordinate of a particle which is confined to move along a straight line is given by 
\[ s = 2t^3 - 24t + 6, \]
where \( s \) is measured in meters from a convenient origin and \( t \) is in seconds. 
Determine (a) the time required for the particle to reach a velocity of 72 m/s from its initial condition 
at \( t = 0 \), (b) the acceleration of the particle when \( v = 30 \) m/s, and (c) the net displacement of the particle 
during the interval from \( t = 1 \) s to \( t = 4 \) s.
A test projectile is fired horizontally into a viscous liquid with a velocity of $v_0$. 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.
A car starts from rest and accelerates at a constant rate until it reaches 100 km/h in a distance of 60 m, at which time the clutch is disengaged. The car then slows down to a velocity of 50 km/h in an additional distance of 120 m with a deceleration which is proportional to its velocity. Find the time $t$ for the car to travel the 180 m.
A long jumper approaches his takeoff board $A$ with a horizontal velocity of 10 m/s. Determine the vertical component $v_y$ of the velocity of his center of gravity (CG) at takeoff for him to make the jump shown. What is the vertical rise $h$ of his CG.
For a certain interval of motion, the pin $P$ is forced to move in the fixed parabolic slot by the vertical slotted guide, which moves in the $x$-direction at the constant rate of 20 mm/s. All measurements are in millimeters and seconds. Calculate the magnitudes of the velocity $v$ and acceleration $a$ of pin $P$ when $x = 60$ mm.
To anticipate the dip and hump in the road, the driver of a car applies her brakes to produce a uniform deceleration. Her speed is 100 km/h at the bottom $A$ of the dip and 50 km/h at the top $C$ of the hump, which is 120 m along the road from $A$. If the passengers experience a total acceleration of 3 m/s$^2$ at $A$ and if the radius of curvature of the hump at $C$ is 150 m, calculate (a) the radius of curvature $\rho$ at $A$, (b) the acceleration at the inflection point $B$, and (c) the total acceleration at $C$. 

![Diagram of the road with points A, B, and C labeled and distances of 60 m and 150 m indicated.]
A rocket traveling above the atmosphere at an altitude of 500 km would have a free-fall acceleration $g = 8.43 \, \text{m/s}^2$ in the absence of forces other than gravitational attraction. Because of thrust, however, the rocket has an additional acceleration component $a_1$ of $8.80 \, \text{m/s}^2$ tangent to its trajectory, which makes an angle of $30^\circ$ with the vertical at the instant considered. If the velocity $v$ of the rocket is 30,000 km/h at this position, compute the radius of curvature $\rho$ of the trajectory and the rate at which $v$ is changing with time.
In the design of a control mechanism, the vertical slotted guide is moving with a constant velocity \( \dot{x} = 150 \text{ mm/s} \) during the interval of motion from \( x = -80 \text{ mm} \) to \( x = +80 \text{ mm} \). For the instant when \( x = 60 \text{ mm} \), calculate the \( n \)- and \( t \)-components of acceleration of the pin \( P \), which is confined to move in the parabolic slot. From these results, determine the radius of curvature \( \rho \) of the path at this position. Verify your result by computing \( \rho \) from the expression cited in Appendix C/10.
The horizontal plunger A, which operates the 70° bell crank BOC, has a velocity to the right of 75 mm/s and is speeding up at the rate of 100 mm/s per second at the position for which $\theta = 30^\circ$. Compute the angular acceleration $\dot{\theta}$ of the bell crank at this instant.
Rotation of the radially slotted arm is governed by $\theta = 0.2t + 0.02t^2$, where $\theta$ is in radians and $t$ is in seconds. Simultaneously, the power screw in the arm engages the slider $B$ and controls its distance from $O$ according to $r = 0.2 + 0.04t^2$, where $r$ is in meters and $t$ is in seconds. Calculate the magnitudes of the velocity and acceleration of the slider for the instant when $t = 3$ s.
The radial position of a fluid particle $P$ in a certain centrifugal pump with radial vanes is approximated by $r = r_0 \cosh K t$, where $t$ is time and $K = \dot{\theta}$ is the constant angular rate at which the impeller turns. Determine the expression for the magnitude of the total acceleration of the particle just prior to leaving the vane in terms of $r_0$, $R$, and $K$. 
The piston of the hydraulic cylinder gives pin $A$ a constant velocity $v = 0.9\, \text{m/s}$ in the direction shown for an interval of its motion. For the instant when $\theta = 60^\circ$, determine $\dot{r}$, $\ddot{r}$, $\dot{\theta}$, $\ddot{\theta}$, where $r = OA$. 

![Diagram of a hydraulic cylinder with a given velocity and angle.]
At the instant depicted, assume that the particle $P$, which moves on a curved path, is 80 m from the pole $O$ and has the velocity $v$ and acceleration $a$ as indicated. Determine the instantaneous values of $\dot{r}$, $\ddot{r}$, $\dot{\theta}$, $\ddot{\theta}$, the $n$- and $t$-components of acceleration, and the radius of curvature $\rho$. 
Car $A$ negotiates a curve of 60-m radius at a constant speed of 50 km/h. When $A$ passes the position shown, car $B$ is 30 m from the intersection at the rate of 1.5 m/s$^2$. Determine the acceleration which $A$ appears to have when observed by an occupant of $B$ at this instant.
Airplane $A$ is flying north with a constant horizontal velocity of 500 km/h. Airplane $B$ is flying southwest at the same altitude with a velocity of 500 km/h. From the frame of reference of $A$ determine the magnitude $v_r$ of the apparent or relative velocity of $B$. Also find the magnitude of the apparent velocity $v_n$ with which $B$ appears to be moving sideways or normal to its centerline. Would the results be different if the two airplanes were flying at different but constant altitudes?
Airplane $A$ is flying horizontally with a constant speed of 200 km/h and is towing the glider $B$, which is gaining altitude. If the tow cable has a length $r = 60$ m and $\theta$ is increasing at the constant rate of 5 degrees per second, determine the magnitudes of the velocity $v$ and acceleration $a$ of the glider for the instant when $\theta = 15^\circ$. 

![Diagram of airplanes $A$ and $B$ with tow cable and angles $\theta$ and $r$.]
The motion of pin $P$ is controlled by the two moving slots $A$ and $B$ in which the pin slides. If $B$ has a velocity $v_B = 3 \text{ m/s}$ to the right while $A$ has an upward velocity $v_A = 2 \text{ m/s}$, determine the magnitude $v_P$ of the velocity of the pin.