2/142 At the bottom of a loop in the vertical (r-θ) plane at an altitude of 400 m, the airplane P has a horizontal velocity of 900 km/h and no horizontal acceleration. The radius of curvature of the loop is 1200 m. For the radar tracking at O, determine the recorded values of \( r \) and \( \dot{r} \) for this instant.

![Diagram of airplane P with coordinates and distances](image)

2/145 The slider P can be moved inward by means of the string S, while the slotted arm rotates about point O. The angular position of the arm is given by \( \theta = \frac{2t}{20} \), where \( t \) in radians and \( t \) is in seconds. The slider is at \( r = 1.6 \) m when \( t = 0 \) and thereafter is drawn inward at the constant rate of 0.2 m/s. Determine the magnitude and direction (expressed by the angle \( \alpha \) relative to the x-axis) of the velocity and acceleration of the slider when \( t = 4 \) s.

\[ \text{Ans.} \quad v = 0.577 \text{ m/s} \quad \alpha = 283^\circ \quad a = 0.275 \text{ m/s}^2 \quad \alpha = 19.44^\circ \]

2/150 For an interval of motion the drum of radius \( h \) turns clockwise at a constant rate \( \omega \) in radians per second and causes the carriage P to move to the right as the unwound length of the connecting cable is shortened. Use polar coordinates \( r \) and \( \theta \) and derive expressions for the velocity \( \dot{r} \) and acceleration \( \ddot{r} \) of P in the horizontal guide in terms of the angle \( \theta \). Check your solution by a direct differentiation with time of the relation \( x^2 + h^2 = r^2 \).

![Diagram of drum and carriage](image)

2/152 The piston of the hydraulic cylinder gives pin A a constant velocity \( v = 3 \) ft/sec in the direction shown for an interval of its motion. For the instant when \( \theta = 60^\circ \), determine \( \dot{r} \), \( \dot{r} \), \( \dot{\theta} \), and \( \ddot{\theta} \) where \( r = OA \).

![Diagram of hydraulic cylinder](image)

2/162 The baseball player of Prob. 2/120 is repeated here with additional information supplied. At time \( t = 0 \), the ball is thrown with an initial speed of 100 ft/sec at an angle of 30° to the horizontal. Determine the quantities \( r \), \( \dot{r} \), \( \theta \), \( \dot{\theta} \), and \( \ddot{\theta} \), all relative to the x-y coordinate system shown, at time \( t = 0.5 \) sec.

\[ \text{Ans.} \quad r = 51.0 \text{ ft}, \quad \dot{r} = 94.4 \text{ ft/sec} \quad \theta = 31.9^\circ \quad \ddot{\theta} = 0.034 \text{ rad/sec}^2 \quad \dot{\theta} = 0.850 \text{ rad/sec}^2 \]

2/163 An earth satellite traveling in the elliptical orbit shown has a velocity \( v = 12,149 \) mi/hr as it passes the end of the semiminor axis A. The acceleration of the satellite at A is due to gravitational attraction and is \( 32.24(8859/8400)^2 = 7.159 \text{ ft/sec}^2 \) directed from A to C. For position A calculate the values of \( \dot{r} \), \( \ddot{r} \), \( \dot{\theta} \), and \( \ddot{\theta} \).

\[ \text{Ans.} \quad \dot{r} = 8910 \text{ ft/sec} \quad \ddot{r} = -1.799 \text{ ft/sec}^2 \quad \dot{\theta} = 3.46 \times 10^{-4} \text{ rad/sec} \quad \ddot{\theta} = -1.398 \times 10^{-7} \text{ rad/sec}^2 \]

![Diagram of earth satellite](image)
The small block $P$ travels with constant speed $v$ in the circular path of radius $r$ on the inclined surface. If $\theta = 0$ at time $t = 0$, determine the $x$-, $y$-, and $z$-components of velocity and acceleration as functions of time.

An aircraft $P$ takes off at $A$ with a velocity $v_0$ of 250 km/h and climbs in the vertical $y'$-$z'$ plane at the constant 15° angle with an acceleration along its flight path of 0.8 m/s$^2$. Flight progress is monitored by radar at point $O$. Resolve the velocity of $P$ into cylindrical-coordinate components 60 s after takeoff and find $\dot{r}$, $\theta$, and $z$ for that instant. (Suggestion: Draw the related $x'$-$y'$ and $x'$-$z'$ projections of the velocity components.)

The robotic device of Prob. 2/153 now rotates about a fixed vertical axis while its arm extends and elevates. At a given instant, $\phi = 30^\circ$, $\dot{\phi} = 10$ deg/s = constant, $l = 0.5$ m, $\dot{l} = 0.2$ m/s, $\ddot{l} = -0.3$ m/s$^2$, and $\Omega = 20$ deg/s = constant. Determine the magnitudes of the velocity $v$ and the acceleration $a$ of the gripped part $P$.

An aircraft is flying in a horizontal circle of radius $b$ with a constant speed $u$ at an altitude $h$. A radar tracking unit is located at $C$. Write expressions for the components of the velocity of the aircraft in the spherical coordinates of the radar station for a given position $\beta$.

\[
\begin{align*}
\text{Ans. } &v_r = \frac{bu \sin \beta}{\sqrt{4b^2 \sin^2 \frac{\beta}{2} + h^2}}, \quad v_\phi = \frac{uh \cos \frac{\beta}{2}}{\sqrt{4b^2 \sin^2 \frac{\beta}{2} + h^2}}
\end{align*}
\]

In a design test of the actuating mechanism for a telescoping antenna on a spacecraft, the supporting shaft rotates about the fixed $z$-axis with an angular rate $\dot{\theta}$. Determine the $R$, $\theta$, and $\phi$-components of the acceleration $a$ of the end of the antenna at the instant when $L = 1.2$ m and $\beta = 45^\circ$ if the rates $\dot{\theta} = 2$ rad/s, $\dot{\beta} = \frac{3}{2}$ rad/s, and $\dot{L} = 0.9$ m/s are constant during the motion.