1. (20) A car is traveling at 72 km/h when the driver notices the traffic light turning red 100 m ahead. Determine the minimum constant deceleration required to stop the car if:
   (a) the driver immediately steps on the brake
   (b) the driver hesitates for 1 s before stepping on the brake
   Ans. 2 m/s², 2.5 m/s²

2. (20) A 1 kg mass is placed on a string which is wrapped at a radius \( r = 30 \) cm around a drum with a moment of inertia \( I = 50 \) kgm². How long will it take the mass to fall 1 m?
   Ans. 10.62 s

3. (20) The 220-mm-diameter bowling ball has a mass of 7.25 kg. The instant that the ball comes in contact with the alley, it has a forward velocity \( v \) of 7 m/s and a backspin \( \omega \) of 6 rad/s. If the kinetic coefficient of friction between the ball and the alley is 0.15, determine the elapsed time and the distance traveled before the ball begins to roll without slipping.
   Ans. 1.489 s, 8.79 m

4. (20) Two spheres are hanging from two cords as shown. The distance from the ceiling to the center of each sphere is 2m, and the coefficient of restitution is 0.75. If sphere A (\( m_A = 2 \) kg) is drawn back 60° and released from rest, determine:
   (a) the maximum angle \( \theta_B \) that sphere B (\( m_B = 3 \) kg) will swing as a result of the impact
   (b) the angle \( \theta_A \) that sphere A will rebound
   Ans. 40.99 degrees, 2.85 degrees
5. (20) Blocks A and B weigh 14.6 and 7.3 kg respectively. With $\mu = 0.2$ between A and B, and $\mu = 0$ between A and the ground, determine the maximum force $F$ that can be applied without B slipping off A.

Ans. 239.82 N
Equation Sheet

\[
\begin{align*}
\frac{dv}{dt} &= a \\
\frac{d^2x}{dt^2} &= \frac{dv}{dx}
\end{align*}
\]

Uniform rectilinear motion
\[x = x_0 + vt\]

Uniformly accelerated rectilinear motion
\[v = v_0 + at\]
\[x = x_0 + v_0 t + \frac{1}{2}at^2\]
\[v^2 = v_0^2 + 2a(x - x_0)\]

Acceleration components

Tangential & normal:
\[a_t = \frac{dv}{dt}, \quad a_n = \frac{v^2}{\rho}\]

Radial and transverse:
\[a_r = \ddot{r} - r\ddot{\theta}^2, \quad a_\theta = r\ddot{\theta} + 2\dot{r}\dot{\theta}\]

Work and energy:
\[T_1 + U_{1\to 2} = T_2\]

Conservation of energy:
\[T_1 + V_1 = T_2 + V_2\]

Impulse and momentum:
\[m\ddot{v}_1 + \int_{t_1}^{t_2} \vec{F} \, dt = m\ddot{v}_2\]

Coefficient of restitution:
\[e = \frac{v_1' - v_2'}{v_1' - v_2}\]

\[\ddot{v}_B = \ddot{v}_A + \ddot{v}_{B/A} = \ddot{v}_A + \ddot{\omega} \times \dddot{r}_{B/A}\]
\[\ddot{a}_B = \ddot{a}_A + \dddot{a}_{B/A} = \ddot{a}_A + \left( \dddot{a}_{B/A} \right)_r + \left( \dddot{a}_{B/A} \right)_n\]
\[(a)_r = r\ddot{\omega}, \quad (a)_n = r\dddot{\omega}\]
\[\sum \vec{F} = m\ddot{a}_G, \quad \sum \vec{M}_G = I_G \ddot{\alpha}\]

Impulse and momentum for rigid bodies:
\[m\ddot{v}_{G1} + \int_{t_1}^{t_2} \vec{F} \, dt = m\ddot{v}_{G2}\]
\[I_G \ddot{\alpha}_1 + \int_{t_1}^{t_2} \vec{M}_G \, dt = I_G \ddot{\alpha}_2\]

For a uniform cylinder, \(I_G = \frac{1}{2}mr^2\)
For a uniform rod, \(I_G = \frac{1}{12}ml^2\)
For a uniform sphere, \(I_G = \frac{2}{5}mr^2\)