1. (30) A sprinter reaches his maximum speed $v_{\text{max}}$ in 2.5 seconds from rest with a constant acceleration. He then maintains that speed and reaches the 100 meters finish line in an overall time of 10.4 seconds. Determine his maximum speed $v_{\text{max}}$.

Ans. 10.93 m/s

2. (30) Determine the relationship which governs the velocities of the four cylinders. Express all velocities as positive down. How many degrees of freedom are there?

Ans. $4v_A + 8v_B + 4v_C + v_D = 0$, 3 DOF

3. (40) A small object $A$ is held against the vertical side of the rotating cylindrical container of radius $r$ by centrifugal action. If the coefficient of friction between the object and the container is $\mu$, determine the expression for the minimum rotational speed $\dot{\theta} = \omega$ of the container which will keep the object from slipping down the vertical side.

Ans. $\omega = \sqrt{\frac{g}{\mu r}}$

Useful equations

- $v = \frac{dx}{dt}$
- $a = \frac{dv}{dt} = \frac{d^2x}{dt^2} = v \frac{dv}{dx}$

Uniform rectilinear motion: $x = x_0 + vt$

Uniformly accelerated rectilinear motion: $v = v_0 + at$, $x = x_0 + v_0t + \frac{1}{2}at^2$, $v^2 = v_0^2 + 2a(x - x_0)$

Acceleration components:

- Tangential & normal: $a_t = \frac{dv}{dt}$, $a_n = \frac{v^2}{\rho}$
- Radial and transverse: $a_r = \ddot{r} - r\dot{\theta}^2$, $a_\theta = r\dot{\theta} + 2\dot{r}\dot{\theta}$