WASHINGTON UNIVERSITY
Department of Mechanical Engineering
ME 232 — Dynamics

TEST 2 — SOLUTIONS

1

(a) \( v_c = -\omega_c \times R \times \hat{r} = v_0 \hat{c} \Rightarrow v_c = -\omega_c \hat{c} \)
\( v_A = v_c + \omega_A \times R \times \hat{C} = v_0 \hat{c} - \omega_c \hat{R} + v_0 \hat{c} - v_0 \hat{r} \)
\( v_A = v_B + \omega_B \times \hat{u} \times \hat{A} = v_B + \omega_B \times (2R \hat{R} + R \hat{j}) \)
\( v_0 \hat{c} - v_0 \hat{r} = v_0 \hat{c} - 2\omega_c \hat{R} - \omega_c \hat{R} \)
\( v_0 \hat{c} - v_0 \hat{r} = \frac{v_0}{2} \hat{R} \)
\( v_B = \frac{v_0}{2} \hat{R} \)
\( \omega \hat{B} = \frac{v_0}{2} \hat{R} \)

2

Pure translation \( (g \times F, m \omega) \)
\( m = 1500 \ kg \)
\( \sum F_x = m a_x = -m g \)
\( \sum F_y = -mg \Rightarrow N_A + N_B - mg = 0 \) ... (1)
\( \sum M_G = I_G \omega^2 \Rightarrow N_A - N_B + N_B - 0.97 \) \( m_g \omega = 0 \) ... (2)
\( \omega \hat{c} \Rightarrow N_B = \frac{m}{2} \hat{g} = 9 \) \( N \)
\( N_A = 0.7 \hat{h} \times 6.34 \) \( N \)
Why no friction force in front wheel?

3

\( \sum F_x = \sum F_y = 0 \)
\( F = F_{in} \hat{x} + (F_{in} \hat{z}) \times (1) - y \hat{k} = -F_{in} \)
\( \sum M = \sum F \times \hat{z} = -\frac{F_{in}}{m} \hat{z} \)

4

Kinematics:
\( v_0 = 72 \ m/s \)
\( v_{fr} = 40 \ m/s \)
\( \theta = \frac{\pi}{2} \)
\( F_{in} = v_{in} \frac{d \theta}{dt} = v_{in} \rho \frac{d \theta}{dt} \)
\( F_{fr} = v_{fr} \frac{d \theta}{dt} = v_{fr} \rho \frac{d \theta}{dt} \)
\( \sum F_x = -F_{in} + F_{fr} - 2 = m a_x = 0 \)

R = \( \frac{F_{in} - F_{fr}}{\rho} (v_{in} - v_{fr}) \)
\( = (1000)(0.0785) \angle (40^\circ - 20^\circ) \)
\( = 157 \) \( \text{N} \)