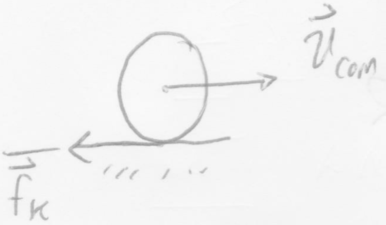
Rolling Ball — First it slides, then it rolls.

15.



$R = 0.11$ m $\quad \mu_K = 0.21$

$V_0 = 8.5$ m/s ← At C.O.M.

$\omega_0 = 0$ rad/s

If rolling, this is where s is distance traveled

$\vec{f}_k$ creates both linear accel. and angular acc.

Ball stops sliding and then rolls smoothly when $\vec{V}_{com}$ decreases enough.

$s = \theta R$ ✓ ⇒ $v = \omega R$

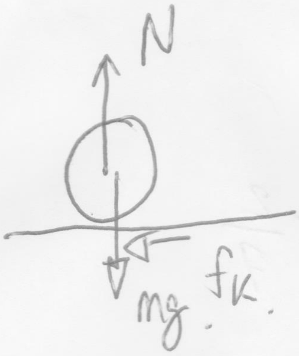
a) $V_{com} = ?$ in terms of ω.

ω going ccw is +. Here ball, rolls cw.

So, $\boxed{V_{com} = -0.11\,\omega}$

~~The tangential~~ velocity V_t must ~~equal V_{com} when the ball is NOT slipping.~~

b) While sliding, $\vec{a} = ?$



$\Sigma F = ma$

$-\mu mg = ma$

$\Rightarrow a = -\mu g$

$= -0.21(9.8)$

$= \boxed{-2.06\,m/s^2}$

Only force that produces a torque about center is f_K.

c) Torque: $f_K R = I\alpha$

$\Rightarrow \mu m g R = \frac{2}{5} m R^2 \alpha$

$F_K = \mu N$

$\Rightarrow \alpha = \frac{5}{2}\,\mu g/R$

$= \frac{5}{2}\,\frac{(0.21)(9.8)}{0.11} = \boxed{-46.7\ rad/s^2}$

15...

d) Time to reach non-slipping point?

When ball starts rolling, $V = \omega R$

Remember $\omega = \alpha t$.

Velocity of ball is

=> ~~$V = (\alpha t R)$~~

$V = \alpha t R$

Kinematics

$V = V_0 + at$

~~At rolling time,~~

=> ~~$\omega R = V_0 + \alpha R t$~~

At rolling time,

$\alpha t R = V_0 - \mu g t$

$\left(\frac{5}{2}\frac{\mu g}{R}\right) t R = V_0 - \mu g t$

$\mu g t \left(\frac{5}{2} + 1\right) = V_0$

$7/2$

$t = \frac{V_0}{\mu g} \cdot \frac{2}{7}$

$= \frac{8.5}{(0.21)(9.8)} \cdot \frac{2}{7}$

$= \boxed{1.19 \text{ sec}}$

15... (e) Distance traveled? $x = ?$

Let's do (f) first.

Use kinematics.

$$v_f^2 - v_0^2 = 2 a x_f$$

$$\Rightarrow \quad x = \frac{6.07^2 - 8.5^2}{2(-2.06)}$$

$$= \boxed{8.6\,m}$$

Alternatively, can do

$$x_f = \cancel{x_0}^{\,0} + v_0 t + \frac{1}{2} a t^2$$

$$= \boxed{8.6\,m}$$

(f) Velocity at time of rolling?

Kinematics

$$V_f = V_0 + a t$$

Plug in t from part (d)

~~$= V_0 + \theta$~~

$$= V_0 - \cancel{\mu g} \cdot \frac{2 V_0}{7 \cancel{\mu g}}$$

$$= \frac{5}{7} V_0$$

$$= \frac{5}{7}(8.5)$$

$$= \boxed{6.07\ m/s}$$