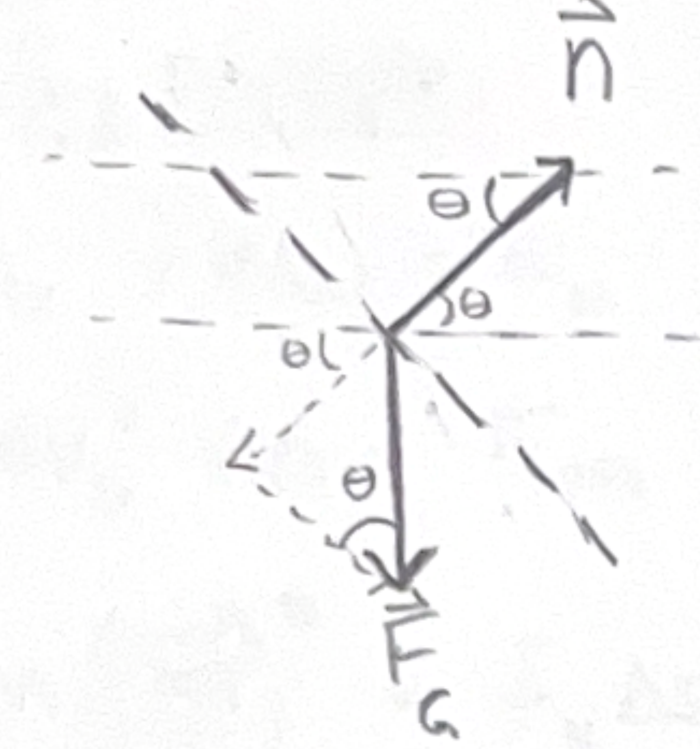
FRQ-7

a) 

be sure you have taken circular motion into account and $n >$ component of F_G parallel to n

b) 

$$\Sigma F_r = n - F_{Gr}$$

$$= \boxed{n - F_G \sin\theta}$$

Alternate solution

① use energy to find v_c

$$E_A = E_C$$

$$Mg\left(R\sin\theta + \frac{3R}{4}\right) = \frac{1}{2}Mv_c^2$$

$$2g\left(R\sin\theta + \frac{3R}{4}\right) = v_c^2$$

② Then, $\Sigma F_r = ma_r$

$$\Sigma F_r = M\left(\frac{v_c^2}{R}\right)$$

$$\Sigma F_r = M\frac{\left(2g\left(R\sin\theta + \frac{3R}{4}\right)\right)}{R}$$

$$\Sigma F_r = \boxed{2Mg\left(\sin\theta + \frac{3}{4}\right)}$$

c) Energy principle from A to D:

$$E_A + W_{ext} = E_D$$

- $W_{ext} = 0$ if the compartment and earth are in the system.
- Initial height above D is $R + \frac{3R}{4} = \frac{7R}{4}$

$$\cancel{m}gh_A + 0 = \frac{1}{2}\cancel{m}v_D^2$$

$$g\left(\frac{7R}{4}\right) = \frac{1}{2}v_D^2$$

$$\boxed{\sqrt{\frac{7gR}{2}} = v_D}$$

d) Using Energy principle:

$E_D + W_{ext} = E_E$

$\frac{1}{2}Mv_D^2 + 0 = E_{th}$

$\frac{1}{2}M\left(\sqrt{\frac{7gR}{2}}\right)^2 = f_k \Delta s$

$\frac{1}{2}M\left(\frac{7gR}{2}\right) = \mu_k Mg\,(3R)$

$\frac{7}{4}MgR = \mu_k Mg\,(3R)$

$\frac{7}{12} = \mu_k$

$\boxed{.58 = \mu_k}$

Using Newton's Laws + Kinematics:

$\Sigma F_x = ma_x$

$-f_k n = Ma_x$

$-\mu_k(Mg) = Ma_x$

$-\mu g = a_x$

$v_{fx}^2 = v_{ix}^2 + 2a_x \Delta x$

$0 = \left(\sqrt{\frac{7gR}{2}}\right)^2 + 2(-\mu g)(3R)$

$0 = \frac{7gR}{2} - 6\mu_k gR$

$-\frac{7gR}{2} = -6\mu gR$

$\frac{7}{12} = \mu_k$

$\boxed{.58 = \mu_k}$

e) i) Differential equation for $v(t)$

$\Sigma F_x = ma_x$

$\boxed{-kv = m\frac{dv}{dt}}$

ii) Solve the differential equation

$-kv = m\frac{dv}{dt}$

$-\frac{k}{m}dt = \frac{dv}{v}$

$\int -\frac{k}{m}dt = \int \frac{dv}{v}$

$-\frac{k}{m}t = \ln v + C$

evaluate C.

At $t = 0$, $v = v_D$

$-\frac{k}{m}(0) = \ln v_D + C$

$-\ln v_D = C$

write expression with the constant value:

$-\frac{k}{m}t = \ln v - \ln v_D$

$-\frac{k}{m}t = \ln\left(\frac{v}{v_D}\right)$

$e^{-\frac{k}{m}t} = \frac{v}{v_D}$

$\boxed{v_D e^{-\frac{k}{m}t} = v}$

iii) Graph of acceleration

$$-kv = ma$$

$$-\frac{kv}{m} = a$$

at $t=0$, $v = V_D$, so

$$a = \frac{kV_D}{m}$$