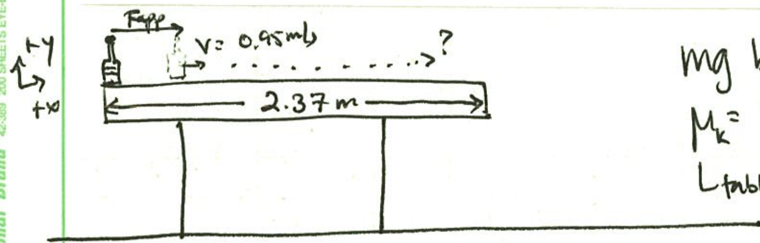
(A) p1.

Tammy and Timmy go to Chipotle for lunch one Saturday. They love their spicy food and so after ordering their burritos, they go to see how many Tabasco bottle are available. However, the day before, students from the local high school had a contest to see how many Tabasco bottles they could steal (they are terrible students) from Chipotle. They were nice enough, however, to leave one bottle left for all of the customers. Now since Tammy and Timmy love their burritos so spicy, they decide to take the bottle to their table. The bottle weighs 2.94 N and has a coefficient of friction of 0.019 with the table they are sitting at. Tammy and Timmy sit across from one another at a table that is 2.37 m long. Tammy is currently drizzling the Tabasco sauce on her burrito when Timmy asks for it. She starts pushing the bottle from her edge of the table with a force of 1.67 N and stops pushing when it reaches a velocity of 0.95 m/s (this was not a conscious decision, it just happened to occur this way).



$mg_{bottle} = 2.94\,N$

$\mu_k = 0.019$

$L_{table} = 2.37\,m$

$F_{appl} = 1.67\,N$

v_f after pushing $= 0.95\,m/s$

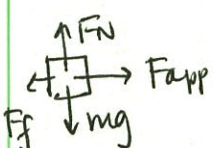
① Find mass:

$mg = 2.94\,N$

so $m = \frac{2.94\,N}{9.8\,m/s^2} = \boxed{0.30\,kg}$

② During time the F is applied:

FBD



$\Sigma F_y = m\cancel{a_y}^{\,0}$ because no y motion

$F_N - mg = 0$

$F_N = mg = \boxed{2.94\,N}$

$\Sigma F = ma$

$F_f = \mu F_N = 0.019(2.94\,N) = \boxed{0.056\,N}$

$\Sigma F_x = ma_x$

$F_{app} - F_f = ma$

$a = \frac{F_{app} - F_f}{m} = \frac{1.67\,N - 0.056\,N}{0.30\,kg} = \boxed{5.38\,m/s^2}$

③ Find time the force is applied:

kinem.

$v_f = v_i + at \Rightarrow t = \frac{v_f - v_i}{a}$

$t = \frac{0.95\,m/s - 0\,m/s}{5.38\,m/s^2} = \boxed{0.18\,sec}$

④ Find W done by Tammy, and power:

$W = Fd\cos\theta = (1.67\,N)(0.087\,m)\cancel{\cos 0} = \boxed{0.145\,J}$ so $P = \frac{W}{t} = \frac{0.145\,J}{0.18\,s} = \boxed{0.81\,W}$

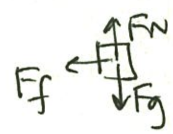
Work/power

I need d! ⑤ $\Delta x = \cancel{v_i t} + \frac{1}{2}at^2 = \frac{1}{2}(5.38\,m/s^2)(0.18\,s)^2$

$\Delta x = \boxed{0.087\,m}$ kin.

⑤ Once Tammy lets go... how far will it travel before stopping? Will it reach the end of the table?

need accel:



$\Sigma F_x = ma$

$-F_f = ma$

$a = \frac{-F_f}{m} = \frac{0.056\,N}{0.30\,kg}$

$\boxed{a = -0.19\,m/s^2}$

FBD + N2L

now: d to stop?

kinem.

$\cancel{v_f}^{\,0\,2} = v_i^2 + 2a\Delta x$

$0 = (0.95\,m/s)^2 + 2(-0.19)\Delta x$

$\boxed{\Delta x = 2.38\,m}$

total dist. traveled $=$

$2.38\,m + 0.087\,m = \boxed{2.47\,m}$

⑥ because it travels > length of table, it will fall off if it isn't caught!

blurb about motion/analysis

(A) p2.

(7) Find v if caught @ edge of table:

kinematics $v_f = v_i + at = (0.95\,m/s) - 0.19\,m/s^2\,(4.02s)$ | need t to end: kinem.

$\boxed{v_f = 0.19\ m/s}$

$\Delta x = v_i t + \frac{1}{2}at^2$

$(2.37m - 0.087m) = (0.95\,m/s)t + \frac{1}{2}(-0.19\,m/s^2)t^2$

$0 = -0.095t^2 + 0.95t - 2.283$

$t = 4.02\,sec$ or $5.98\,sec$

when it reaches that v the 1st time

(8) check w/ energy:

check w/ C of E

$\Sigma \cancel{U_i}^{0} + \Sigma K_i + \Sigma W_{ext} = \Sigma \cancel{U_f}^{0} + \Sigma K_f$

(on level table, so U doesn't change)

$\frac{1}{2}mv_i^2 + Fd\cos 180^{-1} = \frac{1}{2}mv_f^2$

$\frac{1}{2}(0.3kg)(0.95m/s)^2 - (0.056N)(2.37m - 0.087m) = \frac{1}{2}(0.3kg)v_f^2$

$v_f^2 = 0.05018\ldots$

$\boxed{v_f = 0.22\ m/s}$ close! probably rounding error

(9) Let's check another way — how about $F\Delta t = \Delta p$?

check w/ $F\Delta t = \Delta p$

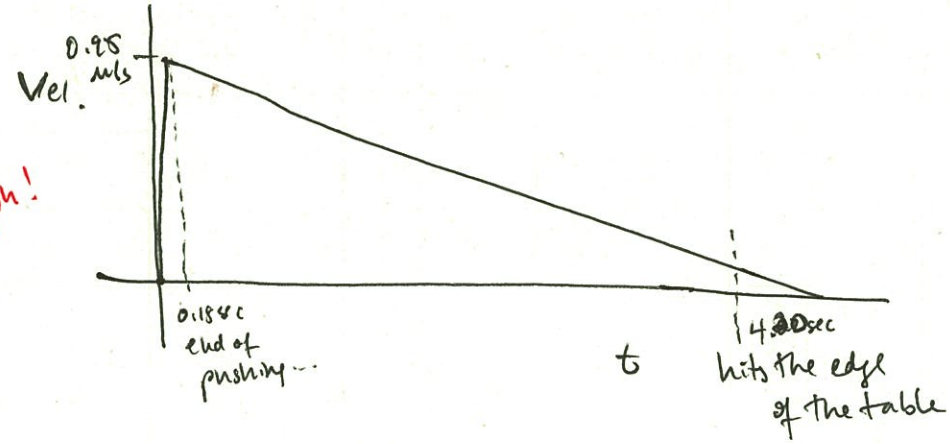
find v_f: $F_{fr}\Delta t = mv_f - mv_i$

$v_f = \dfrac{F_{fr}\Delta t - mv_i}{m} = \dfrac{(-0.056N)(4.02s) - (0.3kg)(0.95m/s)}{0.3kg}$

$\boxed{v_f = 0.20\ m/s}$ right in the middle — all ~same!

(10) Let's graph vel vs t:

Graph!



Problem B

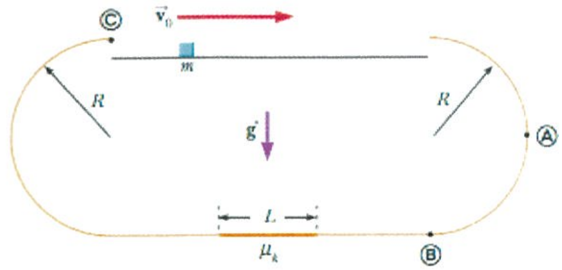


FIGURE P7.58

A small block of mass m = 0.50 kg is fired with an initial velocity v_0 = 4.0 m/s along a horizontal section of frictionless track as shown. The block then slides along the *vertical*, frictionless semicircular track of radius R = 1.5 m (through point A towards point B), until it reaches the level bottom portion of the track. A small section of length L = 0.40 m provides a friction force of 0.83 N before the track becomes frictionless again and the object slides towards point C.

Could be interesting to find: ~~F to get it going, accel, t~~ → not enough info ∴
F_N at A vs B, a_c around curve
v @ B, μ along L, W done by Ff
Does it make it to point C?

(1) Along top flat part:

(1) $mg = (0.50kg)(9.8 m/s^2) = \boxed{4.9 N}$

(2) once sliding $\Sigma F_y = m\cancel{a_y}^{0}$
$N = mg = \boxed{4.9 N}$

At point A:

(3) $\Sigma F_c = ma_c$
$N_A = \frac{mv^2}{R}$

need V @ A:

(4) $\Sigma U_1 + \Sigma K_1 + \cancel{\Sigma W_{ext}} = \Sigma U_2 + \Sigma K_2$
$\cancel{m}gh_i^{2R} + \frac{1}{2}\cancel{m}v_i^2 = \frac{1}{2}\cancel{m}v_A^2 + \cancel{m}gh_A^{R}$
$(9.8 m/s^2)(2(1.5m)) + \frac{1}{2}(4.0 m/s)^2 = \frac{1}{2}v_A^2 + (9.8 m/s^2)(1.5$
$\boxed{v_A = 6.74 m/s}$

$N_A = \frac{(0.50kg)(6.74 m/s)^2}{1.5m}$
$\boxed{N_A = 15.14 N}$

(5) @A! $a_c = \frac{v^2}{R} = \frac{(6.74 m/s)^2}{1.5m} = \boxed{30.3 m/s^2}$

(6) Find velocity @ B:
$\Sigma U_1 + \Sigma K_i + \cancel{\Sigma W_{ext}} = \cancel{\Sigma U_2} + \Sigma K_2$
$\cancel{m}g2R + \frac{1}{2}\cancel{m}v_i^2 = 0 + \frac{1}{2}\cancel{m}v_B^2$
$v_B = \sqrt{2(19.6 m/s^2(1.5m) + \frac{1}{2}(4.0 m/s)^2)}$
$\boxed{v_B = 8.65 m/s}$

(7) B is the very edge of the curve, so use F_c to find N @B:
$\Sigma F_c = ma_c$
$N_B - mg = ma_{c_B}$
$N_B = ma_c + mg = 0.5kg(8.6$
$\uparrow v_B^2/R$ $+ (0.5kg)(9.$
$\boxed{N_B = 29.8 N}$

(8) Along flat bottom track, find μ along L:
$F_f = \mu F_N$
$0.83N = \mu(4.9N)$
$\boxed{\mu = 0.17}$

(9) F_N on length L:
$\Sigma F_y = m\cancel{a_y}^{0}$
$N = mg = \boxed{4.9N}$

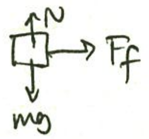
when block hits L, it's still going 8.65 m/s (no friction yet — NIL!)

(B) p2.

(10) W done by F_f along L?

$$W = \vec{F}\cdot\vec{d} = F_f \underset{\uparrow L}{d} \cos 180 = -(0.83\,N)(0.40\,m) = \boxed{-0.332\,J}$$

(11) Use N2L + find v after L:



$$\Sigma F_x = ma_x$$
$$-F_f = ma_x$$
$$-0.83\,N = (0.50\,kg)\,a_x$$
$$\boxed{a_x = -1.66\,m/s^2}$$

(12) now kinematics:

$$V_{after}^2 = V_{before}^2 + 2a\Delta \overset{\swarrow L}{X}$$

$$V_{after} = \sqrt{(8.65\,m/s)^2 + 2(-1.66\,m/s^2)(0.40\,m)}$$

$$\boxed{V_{after} = 8.57\,m/s}$$

(13) Let's check with energy!

$$\cancel{\Sigma U_B} + \Sigma K_B + \Sigma W_{extr} = \cancel{\Sigma U_{after}} + \Sigma K_{after}$$

$$\tfrac{1}{2} m v_B^2 - F_f L = \tfrac{1}{2} m V_{after}^2$$

$$V_{after} = \sqrt{\frac{(0.5\,kg)(8.65\,m/s)^2 - 2(0.332\,J)}{0.50\,kg}}$$

$$\boxed{V_{after} = 8.57\,m/s}$$ ✓ same! yay!

(14) Impulse provided by friction?

$$F\Delta t = \Delta p = mV_{after} - mV_B = (0.50\,kg)(8.57\,m/s - 8.65\,m/s) = \boxed{-0.040\,N\cdot s}$$

(15) t spent sliding on L?

$$\Delta p = F\Delta t \text{ so } \Delta t = \frac{\Delta p}{F} = \frac{-0.040\,N\cdot s}{-0.83\,N} = \boxed{0.048\,sec}$$

(16) Does it make it to C? Find v @ C:

$$\cancel{\Sigma U_{bottom}} + \Sigma K_{bottom} + \cancel{\Sigma W_{ext}} = \overset{\swarrow mg(2R)}{\Sigma U_C} + \Sigma K_C$$

$$\tfrac{1}{2}(0.5\,kg)(8.57\,m/s)^2 = (0.5\,kg)(9.8\,m/s^2)(3.0\,m) + \tfrac{1}{2}(0.50\,kg)V_C^2$$

$$\boxed{V_C = 3.83\,m/s}$$

(17) To make it around the curve @ C, must exceed critical v:

$$\Sigma F_c = ma_c = \frac{mv^2}{R}$$

$$N + mg = \frac{mv^2}{R}$$

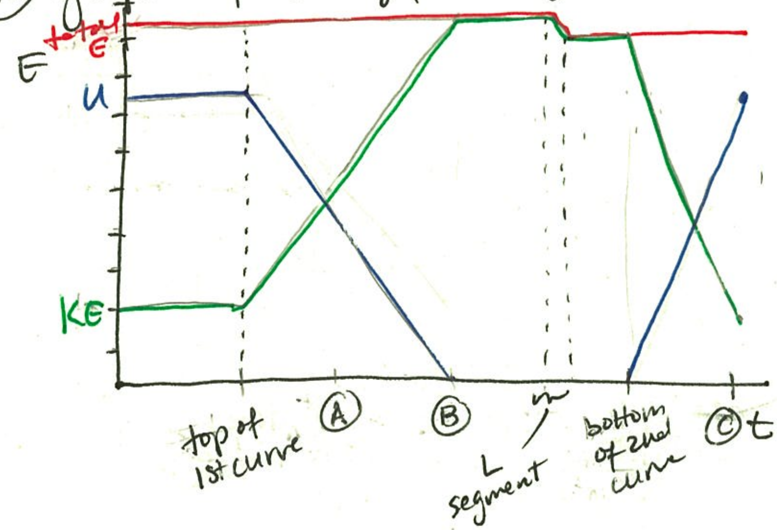
@ critical v, $N \to 0$:

$$\cancel{m}g = \frac{\cancel{m}v^2}{R} \quad v = \sqrt{Rg} = \sqrt{(1.5\,m)(9.8\,m/s^2)} = \boxed{3.83\,m/s}$$

it just makes it!

(B) p3.

(18) graph of Energy Throughout (starting @ $v_i = 4.0$ m/s)



$U_i \approx mg2R = (0.5)(9.8)(3) = 14.7$ J

$K_i = \frac{1}{2}mv_i^2 = \frac{1}{2}(0.5)(4^2) = 4$ J

$K_B = \frac{1}{2}mv_B^2 = \frac{1}{2}(0.5)(8.65^2) = 18.7$ J

$K_{after\,L} = K_c - W_{fr} = 18.7\text{ J} - 0.332\text{ J}$

18.37 J

new E_{total}

$U @ C = 14.7$ J

$KE @ C = 18.37 - 14.7 = 3.67$ J

(D) pl.

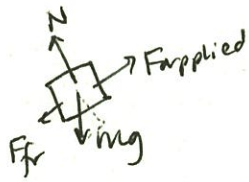
A new event at the Winter Olympics in Sochi is uphill log pulling. This event requires athletes to pull a log up a hill as far as they can and for as long as they can. Since it's a new event, not many individuals applied to compete. The hill is at an angle of 27.1 degrees and the coefficient of friction between the log and the hill is 0.23. The first individual, representing the Island of Madagascar, pulled a log that has a mass of 7.8 kg for 11.2 s with a force of 54.6 N. The second athlete, from Mongolia, pulled a log that has a mass of 3.9 kg for 16.167 s for a total distance of 32.67 m.

Who wins? Need to compare distance pulled + time it took, but could be interesting to look at strength/power too...

Madagascar's athlete

given: $m = 7.8\,kg$
$t = 11.2\,sec$
$F_{app} = 54.6\,N$

(1) FBD while pulling:



(2) Fg and FN:

$F_g = mg = (7.8kg)(9.8m/s^2) = \boxed{76.44\,N}$

$\Sigma F_y = m\cancel{a_y}^{0}$ → $N = mg\cos\theta$

$F_N - F_g\cos\theta = 0$

$N = (76.44N)\cos 27.1°$

$\boxed{N = 68.0\,N}$

(3) Find F_f:

$F_f = \mu F_N = (0.23)(68.0N) = \boxed{15.64\,N}$

(4) Find accel: $\Sigma F_x = ma_x$

$F_{appl} - F_{fr} - mg\sin\theta = ma_x$

$a_x = \dfrac{F_{appl} - F_{fr} - mg\sin\theta}{m}$

$\boxed{\Sigma F_x = 4.14N}$

$a_x = \dfrac{54.6N - 15.64N - (76.44)\sin 27.1}{7.8kg}$

$\boxed{a_x = 0.53\,m/s^2}$

(5) Find distance:

$\Delta x = \cancel{v_i t}^{0} + \frac{1}{2}at^2$

$\Delta x = \frac{1}{2}(0.53m/s^2)(11.2s)^2$

$\boxed{\Delta x = 33.24\,m}$

greater distance than Mongolia's athlete but shorter time

(6) work done?

$W_{by\,guy} = F_{appl}\,d\,\cancel{\cos\theta}^{1} = (54.6N)(33.24m) = \boxed{1815\,J}$

$P_{guy} = W/t = 1815\,J/11.2s = \boxed{162\text{ watts}}$

(7) ΣW? $\Sigma W_{extr} = W_{by\,guy} + W_{by\,frict} = 1815J + (15.64N)(33.24m)\cancel{\cos 180}^{-1}$

$\Sigma W = \boxed{1296\,J}$

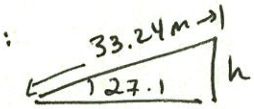
(8) Impulse - Δp → find v_f? $F\Delta t = m(v_f - \cancel{v_i}^{0})$ want $\Sigma F_x = 4.14N$

$v_f = \dfrac{F\Delta t}{m} = \dfrac{(4.14N)(11.2s)}{7.8kg} = \boxed{5.94\,m/s}$

(9) check v_f using kinematics:

$$v_f = v_i + at = 0 + (0.53\,m/s^2)(11.2\,s) = \boxed{5.94\,m/s} \checkmark \text{ same!}$$

(10) check ΣW_{done} using C of E → need h_f:



$$\cancel{\Sigma K_1}^{0} + \cancel{\Sigma U_1}^{0} + \Sigma W_{extr} = \Sigma K_2 + \Sigma U_2$$

$h = (33.24m)\sin 27.1$

$\boxed{h = 15.14m}$

$$\Sigma W_{extr} = \frac{1}{2}mv_f^2 + mgh_f$$

$$\Sigma W_{extr} = \frac{1}{2}(7.8kg)(5.94\,m/s)^2 + (7.8kg)(9.8\,m/s^2)(15.14m)$$

$\boxed{\Sigma W_{extr} = 1295\,J}$ same as before! :)
(close enough...)

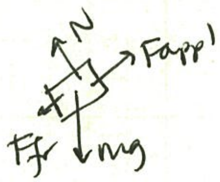
(11) Let's look @ Mongolian athlete: $m = 3.9kg$, $t = 16.17s$, $d = 32.67m$

find accel: $\Delta x = \cancel{v_i t} + \frac{1}{2}at^2$

$$32.67m = \frac{1}{2}a(16.17s)^2$$

$\boxed{a = 0.25\,m/s^2}$

(12) FBD + calc forces acting on log using N2L:



$mg = (3.9kg)(9.8\,m/s^2) = \boxed{38.22N}$

$\Sigma F_y = m\cancel{a_y}^{0}$

$N - mg\cos\theta = 0$

$N = mg\cos\theta = (38.22N)\cos 27.1 = \boxed{34.0N}$

$F_{fr} = \mu F_N = 0.23(34.0N) = \boxed{7.82N}$

$\Sigma F_x = ma_x$

$\Sigma F_x = ma = (3.9kg)(0.25\,m/s^2) = \boxed{0.975N}$

$F_{appl} - F_{fr} - mg\sin\theta = ma_x$

$F_{appl} = ma_x + F_{fr} + mg\sin\theta = (3.9kg)(0.25\,m/s^2) + 7.82N + (38.22N)\sin 27.1$

$\boxed{F_{appl} = 26.2N}$ less force than the other

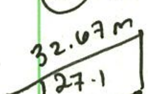
(13) Work + power by this athlete:

$W = F_{appl}\,d\cos 0 = (26.2N)(32.67m) = \boxed{856J}$

$P = W/t = \frac{856J}{16.17s} = \boxed{52.9W}$

way less powerful than the other!

(14) h?



$h = \boxed{14.9m}$

32.67 sin 27.1

(15) use C of E + get v_f:

$\cancel{\Sigma U_1} + \cancel{\Sigma K_1} + \Sigma W_{extr} = \Sigma U_2 + \Sigma K_2$

$\Sigma F_{extr} d\cancel{\cos\theta} = mgh + \frac{1}{2}mv_f^2$

$F_{appl} + F_{fr}$ down

$(26.2N - 7.82)(32.67m) = (3.9)(9.8)(14.9) + \frac{1}{2}(3.9)v_f^2$

$\boxed{v_f = 3.99\,m/s}$

(16) check w/ kin:

$v_f = \cancel{v_i} + at$

$v_f = (0.25)(16.17)$

$= \boxed{4.04\,m/s}$

Ⓓ p3.

(17) displ. vs t graph to visualize difference: