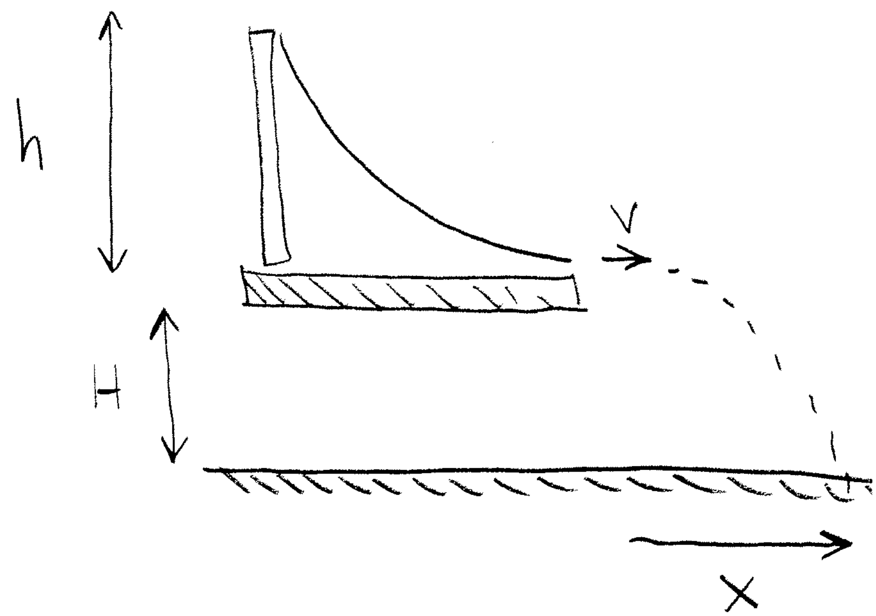
Car at top of track rolls down to table, flies off table with speed v, then falls to floor.



a) At top of track,

$$E_{tot} = KE + GPE = 0 + mgh$$

(use table as zero point of GPE)

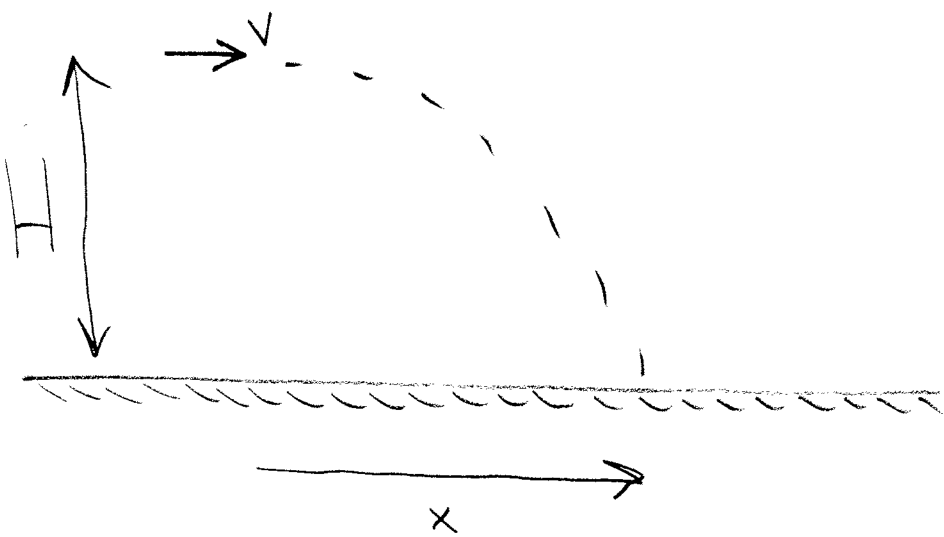
b) When car at table, about to fly through air,

$$E_{tot} = KE + GPE = \frac{1}{2}mv^2 + 0$$

c) so

$$\frac{1}{2}mv^2 = mgh$$

$$\rightarrow \quad v = \sqrt{2gh}$$



d) Car falls a height H due to gravity.

$$(y-y_0) = v_y t + \tfrac{1}{2} a_y t^2$$

$$(0-H) = 0 + \tfrac{1}{2}(-g)\,t^2$$

$$\rightarrow t = \sqrt{\frac{2H}{g}}$$ time to fall to floor

So

$$x = vt = \sqrt{2gh}\,\sqrt{\frac{2H}{g}}$$

$$= 2\sqrt{hH}$$

e) does <u>not</u> depend on mass of car

f) does <u>not</u> depend on value of "g"

In actual experiment in class with Hot Wheels car,

$$m = 35\ g = 0.035\ kg$$

$$h = 61\ cm = 0.61\ m$$

$$H = 89.5\ cm = 0.895\ m$$

So

f) $E_{tot} = KE + GPE$

$= 0 + mgh$ at top of track

$= 0.209\ J$ at top of track

g) we predict

$$v = \sqrt{2gh} = 3.46\ m/s$$

h) we predict

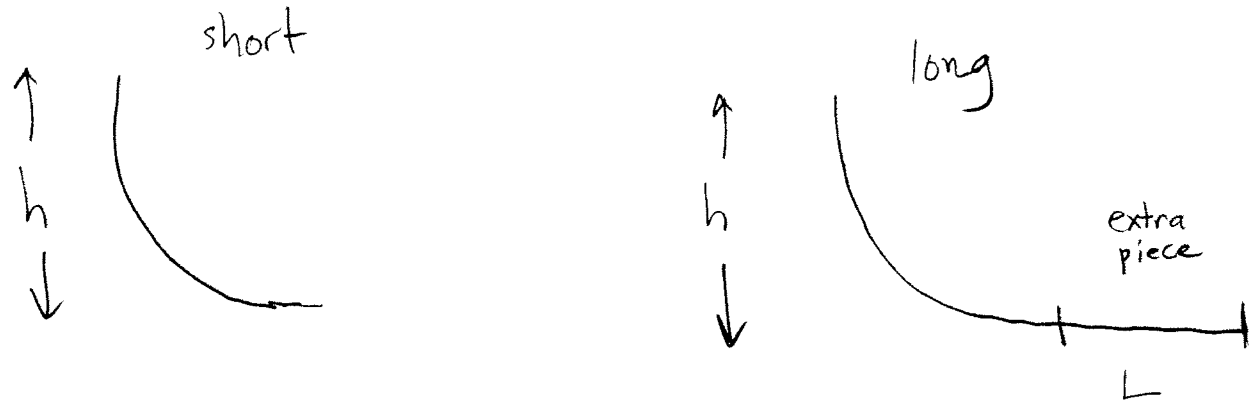
$t = \sqrt{\frac{2H}{g}} = 0.427\ s$ to drop to ground

$$\Rightarrow x = vt = (3.46\,\tfrac{m}{s})(0.427\,s)$$

$$= \boxed{1.48\ m}$$

i) If no friction, yes, any track with $h = 61\ cm$ should send car this same distance.

In the actual experiment, we had two tracks:



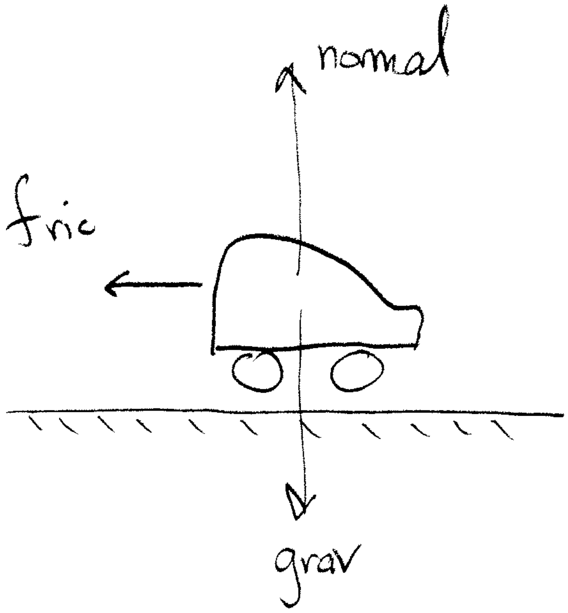
The long track had one extra piece of plastic, of length $L = 54$ cm, which was (basically) flat on the table.

When we rolled car down these tracks, we found

	short	long
actual dist X	1.28 m	1.25 m
actual speed V	$V = \frac{1.28 \text{ m}}{0.427 \text{ s}} = 2.998 \text{ m/s}$	$V = \frac{1.25 \text{ m}}{0.427 \text{ s}} = 2.927 \text{ m/s}$
actual KE	$KE = \frac{1}{2}mv^2 = 0.157 \text{ J}$	$= 0.150 \text{ J}$

Remember the predicted KE was 0.209 J, so both tracks must have caused losses of energy due to friction.

We can make a rough estimate of the coeff of friction between track and car like so: $\longrightarrow$



The longer track had one extra section of length L, and it lost more energy due to friction.

short: lost 0.052 J to friction
long: lost 0.059 J to friction

	x	y
grav	0	$-mg$
normal	0	$+F_N$
fric	$-F_f$	0
tot	$-ma_x$	0

So the long track lost an extra 0.007 J of energy due to friction along that extra length of track. We can compute

$$F_N = mg$$

$$F_f = \mu_K F_N = \mu_K mg$$

So

$$W_{fric} = \int \vec{F_f} \cdot \vec{dx} = -\int |F_f||dx|$$

$$= -\mu_K mg \int_0^L dx \quad \text{over extra length}$$

$$-0.007\,J = -\mu_K mgL$$

So

$$\mu_K \cong \frac{0.007\,J}{mgL} = \underline{\underline{0.038}} \quad \text{rough estimate}$$