PS 14

1. a. Using conservation of energy

\[ E_i = KE + PE = KE + 0 = \frac{1}{2} mv^2 = \frac{1}{2} (0.65 \text{ m/s})^2 (1200) = \approx 254J \]

\[ E_f = KE + PE = 0 + PE_{spring} = \frac{1}{2} kx^2 = \frac{1}{2} k (0.09 \text{ m})^2 \]

No dissipative forces so energy in car transferred 100% to potential in spring

\[ 254 = \frac{1}{2} k (0.09)^2 \rightarrow k = \approx 63,000 \]

b. Next value up! We want spring to compress a maximum of 9 cm.

c. (Note car is sliding)

Energy dissipated by friction: \( E_d = W = (\mu_k N) \cdot d \)

\[ E_d = (1200 \cdot g) (0.094) (0.09 \text{ m}) = (\approx 100 \text{ N}) \]

Thus \( E_f = E_i - E_d = (254 - 100) N = 154 \text{ N} \)

\[ 154 N = \frac{1}{2} kx^2 = \frac{1}{2} k (0.09)^2 \rightarrow k = \approx 38,000 \]

d. At moment car stops \( \mu_k \) turns to \( \mu_s \). If car is not moving, force of spring = force static friction.

\[ F_{spring} = +kx = F_{static-friction} = \mu_s N \ (\text{magnitudes!}) \]
\[ +Kx = \mu_s N \quad \text{(using } k \text{ from } c) \]
\[(38,000)(0.09 \text{ m}) = \mu_s (12,000 \cdot \text{g}) \]
\[\mu_s = 0.029 \]
\[(\mu_s < \mu_k, \text{ not physically realistic})\]

e) Power by spring is work/time

spring does 254 J of work by
\[
W_{\text{net}} = \Delta KE
\]
so \[254/5 = 50.8 \text{ Watts.}\]

f) Want gravitational potential

height: \[mgh = 254 \text{ J}\]
\[h = \frac{254}{(12,000 \cdot \text{g})} = 0.00216 \text{ m}\]

\[\sin (1.23^\circ) = 0.00216 \quad \rightarrow \quad d = 0.10 \text{ m} = 10 \text{ cm}\]