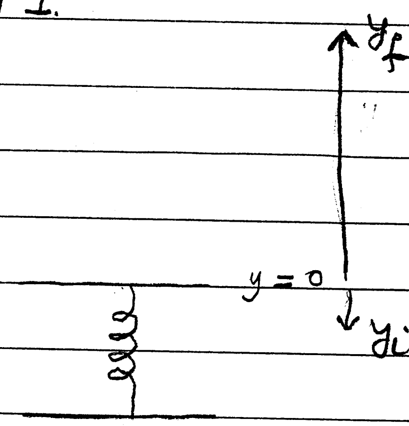
SOLUTIONS — HOMEWORK SET 1.

13–9 Take $y = 0$ at UNCOMPESSED

Then in initial state

$y_i = -0.02$ m.

Vel. $V_i = 0.$



In Final state

$y_f = 0.60$m

Vel $V_f = 0$

$P_{sp} = \frac{1}{2} k y^2$

$P_g = Mgy$

Conservation of Energy

$$P_f + K_f = P_i + K_i$$

$$Mg y_f + 0 = + Mg y_i + \frac{1}{2} k y_i^2 + 0$$

$$k = \frac{2Mg\,(y_f - y_i)}{y_i^2}$$

$$= \frac{2 \times 0.1 \times 9.8\,(0.60 + 0.02)}{(0.02)^2}$$

$$= 3.04 \times 10^3 \text{ N/m}$$

[Note: The answer in the book neglects $Mg y_i$! Presumably, they are assuming that 0.60m is measured from the compressed position).

13-13 mass of bullet

$m_b = 10g$

$= 0.01\,kg$

mass of block

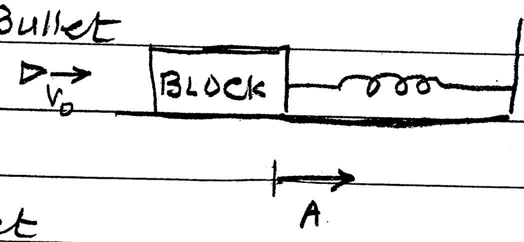
$M_B = 2kg$

velocity of bullet

$\vec{v}_0 = 300\,m/s\ \hat{x}$

spring constant

$k = 19.6\,N/m.$



Let A be the amount of compression.

To solve this problem we have to know the velocity of the Block after the bullet is Embedded in it. This is a totally inelastic collision so only the total momentum is conserved. After the collision the two velocities $\vec{v}_A$ equal

$$(M_B + m_A)\vec{v}_A = m_B \vec{v}_0$$

$$\vec{v}_A = \frac{m_B}{M_B + m_A}\vec{v}_0 = \frac{0.01}{2.01} \times 300\ \hat{x}\ m/s$$

$$= 1.49\,\hat{x}\ m/s.$$

Next, we apply conservation of Energy:

$$P_f + K_f = P_i + K_i$$

$$\frac{1}{2}kA^2 + 0 = 0 + \frac{1}{2}(M_B + m_B)v_A^2$$

$$A = \left(\frac{M_B + m_b}{k}\right)^{1/2} v_A = \left(\frac{2.01}{19}\right)^{1/2} \times 1.49 = \underline{\underline{0.48\,m}}$$

13-14 Mass of Block $M = 1.5\,kg$

Spring Const. $k = 2000\,N/m$.

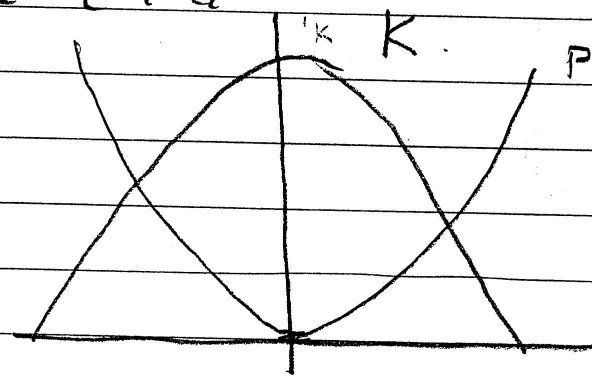
Initial stretch $A = 0.3\,cm = 3\times10^{-3}\,m$.

In the Initial stretch we store Potential Energy in the Mass-spring System

$$P_{sp} = \frac{1}{2} k A^2.$$

a) ~~For (a)~~ the motion obeys energy conservation law (no friction)

$$P_f + K_f = P_i + K_i$$



at $x = 0$

$P_f = 0$

$$\frac{1}{2} M V_0^2 = \frac{1}{2} k A^2.$$

$$V_0 = \sqrt{\frac{K}{M}} \cdot A$$

$$= \sqrt{\frac{2000}{1.5}} \cdot 3\times10^{-3} = 0.109\ m/s$$

(b) For b friction is present $f_k = 2N$

$$P_f + K_f = P_i + K_i + W_{NC}$$

$$= P_i + K_i - f_k \Delta x$$

$$\frac{1}{2} M V_0^2 = \frac{1}{2} k A^2 - f_k A.$$

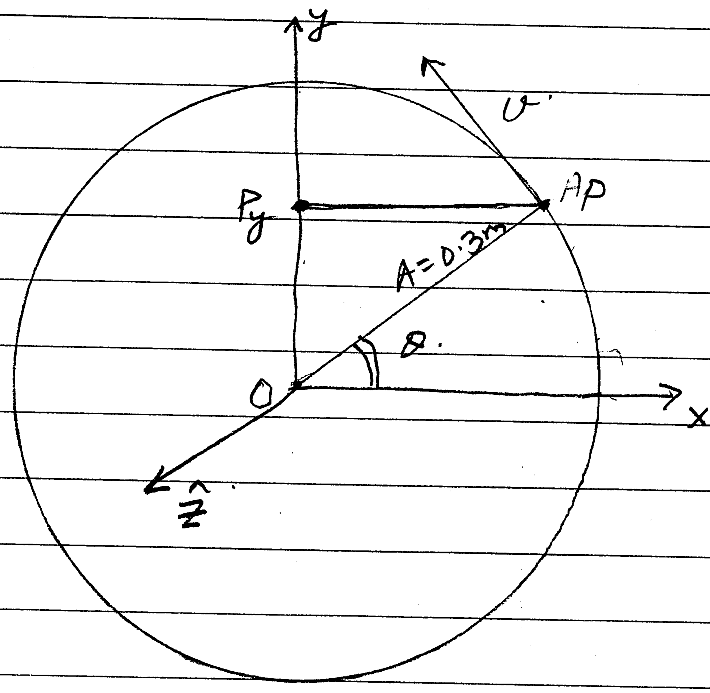
$$\therefore V_0 = \sqrt{\frac{k}{M} A^2 - \frac{2 f_k A}{M}} = \sqrt{12\times10^{-3} - \frac{2\times2\times3\times10^{-3}}{1.5}}$$

$$= \sqrt{12\times10^{-3} - 8\times10^{-3}}\ m/s$$

$$v_0 = \sqrt{4 \times 10^{-3}} \ m/s = 0.063 \ m/s.$$

c). If you increase f_k' to 3 N, v_0 will go to zero.

13-19 Imagine that pt. P is travelling on a circle of radius A at a uniform speed v. Its position vector is



$$\underset{\rightarrow}{r} = A\hat{r}$$

where $\hat{r}$ rotates by ω radian/sec.

ω being the angular velocity

$$\underset{\rightarrow}{\omega} = \frac{v}{A}\hat{z}$$

at any instant (shown at angle θ)

$$\underset{\rightarrow}{r} = A\cos\theta\,\hat{x} + A\sin\theta\,\hat{y}$$

where

$$\theta = (\theta_0 + \omega t)$$

So if you look at the y-component of $\underset{\rightarrow}{r}$, which is what you see on the "bump" in the tire it will vary as

$$y = A\sin(\theta_0 + \omega t)$$

That is simple harmonic motion with amplitude A and angular frequency $\omega = \frac{2\pi}{T}$ where T is the period.

The car travels at 3.00 m/s.
In one period it goes forward by $2\pi A$.
So

$$\frac{2\pi A}{T} = 3.$$

$$T = \frac{2\pi \times A}{3} = \frac{2\pi \times 0.3}{3} = 0.628 \text{ sec.}$$

13-21 Same as 13-19 Except now look at x-component.