# Physics 10154 - Exam #4D

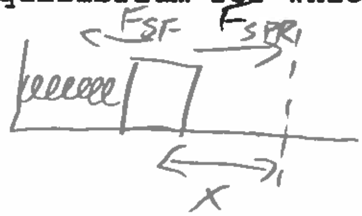
Partial credit will be given provided you show all work and are solving parts of the problem correctly. Points will be deducted if you don't show your work (or if some parts are incorrect) even if you get the right answer. <u>Clearly indicate your answer with a circle or box</u> and remember to include correct <u>units</u> and <u>significant figures</u>.

1. (30 pts) A spring ($k_s$ = 47.0 N/m) lies on a horizontal table, and the left end of the spring is attached to a wall. The other end is connected to a 755-gram block. The coefficient of static friction between the block and the surface is 0.840.

a) If the spring is compressed by 9.11 cm, what is the magnitude and direction of the force of static friction on the block?

b) What is the maximum possible displacement of the spring from equilibrium for which the block will not move?

a)




$\Sigma F_x = +k_s x - F_{SF} = 0$

$F_{SF} = k_s x = (47)(.0911)$

$= \boxed{4.28\ N}$

b) $F_{SF} = \mu_s F_N$ at threshold

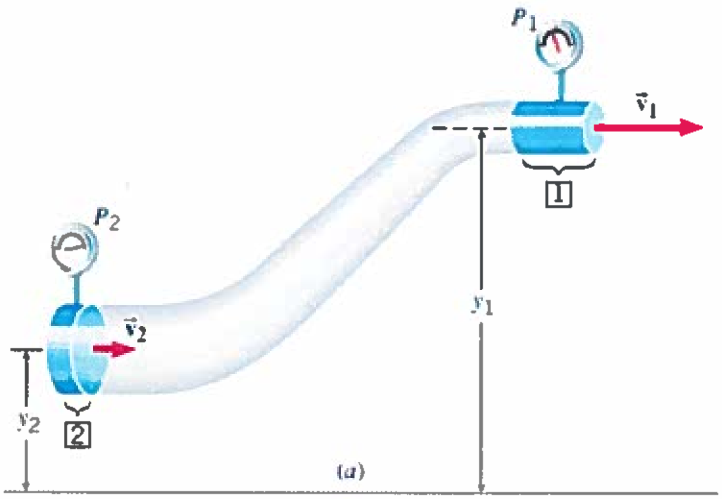
$F_N = mg$ since no other y-forces

$\Sigma F_x = k_s x - \mu_s mg = 0$

$x = \dfrac{\mu_s mg}{k} = \dfrac{(.840)(.755)(9.8)}{47}$

$= \boxed{0.132\ m}$

2. (35 pts) Water flows through a pipe as shown below. The height of the lower end of the pipe, $y_2 = 0$. The height of the upper end, $y_1 = 2.55$ m. The pressure at the lower end of the pipe, $P_2 = 188{,}000$ Pa. The top end of the pipe is open to the atmosphere. The diameter of the pipe at the lower end is 12.0 cm. The diameter of the pipe at the upper end is 8.75 cm. Find (a) the velocity of the water exiting the top end of the pipe and (b) the flow rate (in gallons/sec) of water coming out of the top end of the pipe.




$P_1 = 101{,}300$ Pa, $y_1 = 2.55$ m, $v_1 = ?$ } top

$P_2 = 188{,}000$ Pa, $y_2 = 0$, $v_2 = ?$ } bot

$$P_1 + \rho g y_1 + \tfrac{1}{2}\rho v_1^2 = P_2 + \rho g y_2 + \tfrac{1}{2}\rho v_2^2$$

$$A_1 v_1 = A_2 v_2$$

$$\frac{\pi(.0875)^2}{4} v_1 = \frac{\pi(.120)^2}{4} v_2$$

$$v_1 = 1.88\, v_2$$

$$101300 + (1000)(9.8)(2.55) + 500\,(1.88 v_2)^2 = 188{,}000 + 0 + 500(v_2)^2$$

$$-61710 = -1267\, v^2$$

$$v_2 = 6.98 \text{ m/s}$$

$$\boxed{v_1 = 13.1 \text{ m/s}}$$

$$Q_1 = A_1 v_1 = \frac{\pi(.0875)^2}{4}(13.1) = 0.079 \text{ m}^3/\text{s} \cdot \frac{1 \text{ gal}}{3.786 \times 10^{-3} \text{ m}^3}$$

$$= \boxed{20.8 \text{ gal/s}}$$

3. (35 pts) A 6.50-kg glass bowl ($c = 840$ J/kg · °C) contains 2.00 gallons of punch at 25.0 °C. Treat the punch like water in terms of density and specific heat. 2.50 kg of ice at an initial temperature of -18.0 °C are added to the punch. What is the final temperature of the system? If the final temperature is zero, how much ice melts?

$$m_{punch} = \rho_P V_P = \left(1000 \frac{kg}{m^3}\right)(2.00\,gal)\left(\frac{3.786\times10^{-3}\,m^3}{gal}\right)$$

$$= 7.572\ kg$$

to cool to 0°C

$$\Delta Q_p + \Delta Q_g = (7.572)(4186)(-25) + (6.5)(840)(-25) = -928,910\ J$$

warm to 0°C — melt

$$\Delta Q_{ice} = (2.50)(2010)(18) + (2.50)(333,000) =$$

$$94,050 + 832,500 = 926,550$$

All ice melts, $T_F > 0$.

$$\Delta Q_p + \Delta Q_g + \Delta Q_{ice} = 0$$

$$(7.572)(4186)(T_F - 25) + (6.5)(840)(T_F - 25) + 922,950 + (2.50)(4186)(T_F - 0)$$

$$= 31696\,T_F - 792,410 + 5460\,T_F - 136,500 + 926,550 + 10465\,T_F = 0$$

$$47621\,T_F = 2360$$

$$\boxed{T_F = 0.050°C}$$