Solutions to Homework 5
PHY 132

① We can define temperature so that Temperature is proportional to amplifier gain:

$$\frac{T-20}{60-20} = \frac{29.2-25}{37.4-25}$$

$$T = 20 + 40\left(\frac{4.2}{12.4}\right) = \boxed{33.5^\circ}$$

② ΔT in Celsius $= (100-35)\left(\frac{5}{9}\right) = 36.1\,^\circ C$

$$\Delta l = l\,\alpha_{STEEL}\,\Delta T = 5000\,ft\,(11\times10^{-6})(36.1)$$

$$\boxed{\Delta l = 1.99\ ft}$$

③ Since the pendulum will expand, it will run slower. At 20°C $T_0 = .5$ sec, so in one month $N_0 = \frac{30(24)(3600)}{.5} = 5184000$ oscillations

$T = 2\pi\sqrt{\frac{l}{g}}$ so $\frac{T}{T_0} = \sqrt{\frac{l}{l_0}} = \sqrt{1 + \alpha\,\Delta(\text{Temp})}$

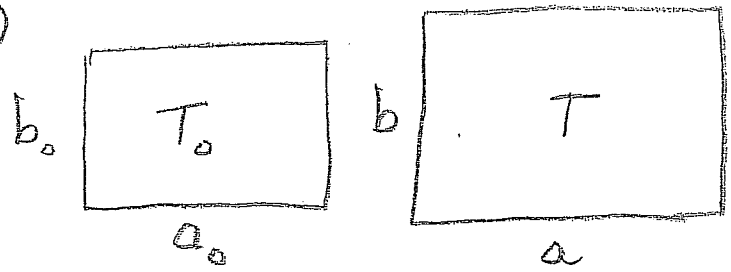
$$\frac{T}{T_0} = \sqrt{1 + 1.2\times10^{-6}(10)} \approx 1.000006$$

So the number of oscillations is $\frac{5184000}{1.000006} \approx 5183969$

$5184000 - 5183969 = 31$ oscillations less or

$31(.5\text{ sec}) \approx \boxed{15.5\text{ sec}}$ slow per month

(4)



$$a = a_0(1+\alpha\Delta T)$$
$$b = b_0(1+\alpha\Delta T)$$

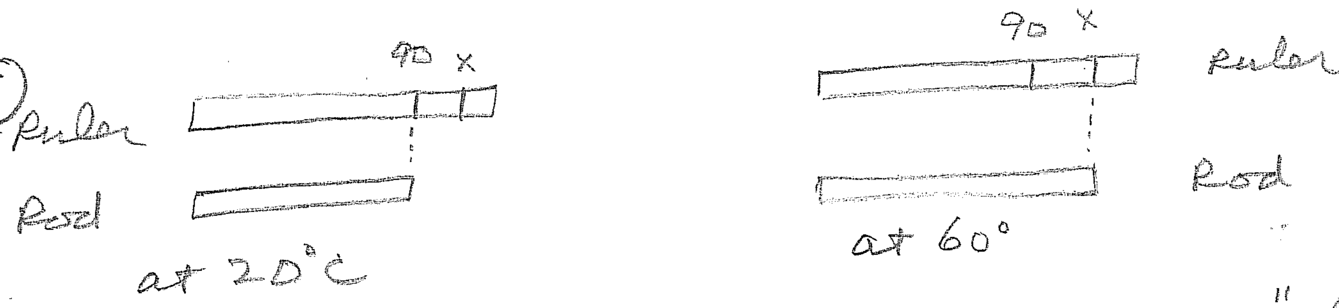
$$A = ab = a_0 b_0 (1+\alpha\Delta T)^2$$
$$A = A_0(1 + 2\alpha\Delta T + \alpha^2\Delta T^2)$$

But, if $\alpha\Delta T << 1$, then

$$A \simeq A_0(1+2\alpha\Delta T) = A_0 + 2\alpha A \Delta T$$

So $\Delta A = A - A_0 \simeq \boxed{2\alpha A \Delta T}$

(5)



Let x be the what the ruler "measures" for the rod at 60°C. Then

$$x(1 + \alpha_{Steel}\, 40) = 90(1 + \alpha_{Brass}\, 40)$$

$$x = \frac{90(1+\alpha_{Brass}\, 40)}{(1+\alpha_{Steel}\, 40)}$$

$$x = \frac{90(1+(1.9\times 10^{-5})40)}{(1+(1.7\times 10^{-5})40)} \approx 90.028 \text{ cm.}$$

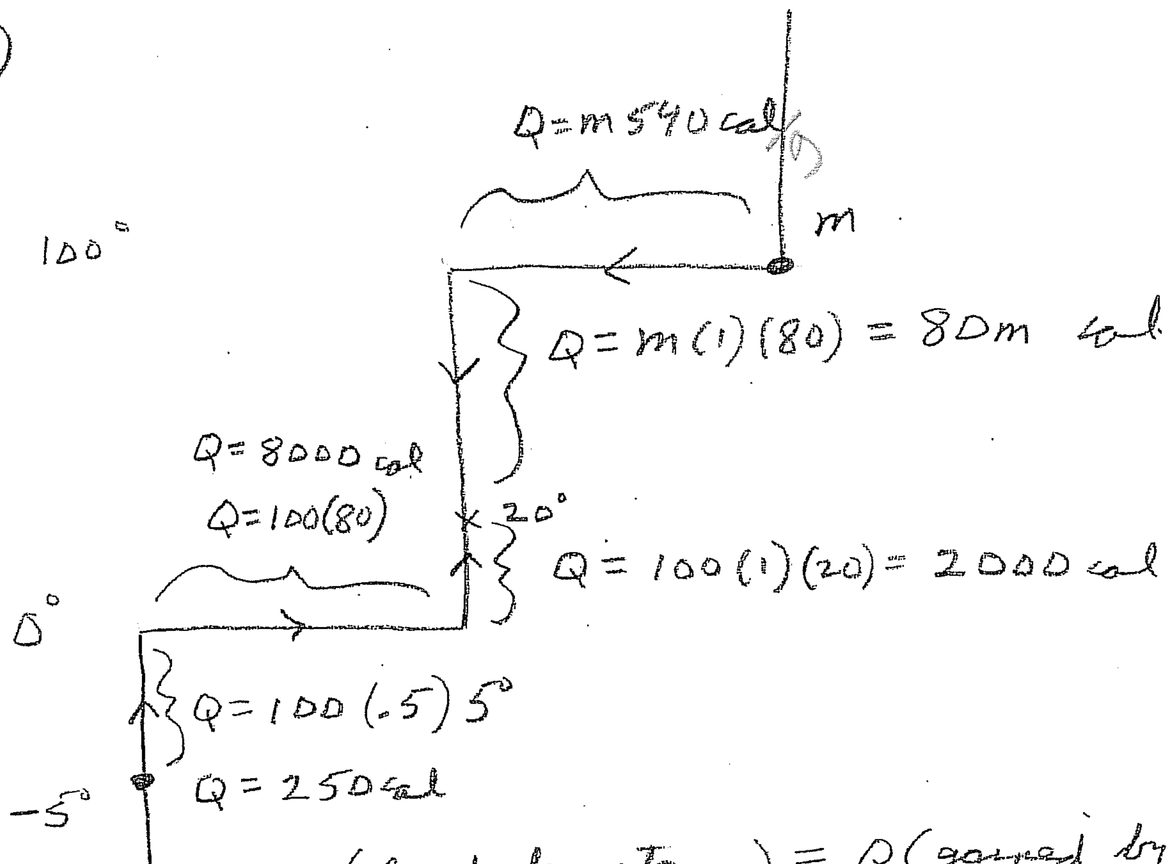
⑥ Energy needed $= mc\Delta T = (200\,\text{Kg})(4190\,\frac{J}{Kg\,°C})(20°C)$

$= 1.68 \times 10^{7}\ J$

$A\left(800\,\frac{J}{s \cdot m^2}\right)(.3)(3600\,\text{sec}) = 1.68 \times 10^{7}\ J$

$\boxed{A = 19.4\,m^2}$

⑦



Q (lost by steam) = Q (gained by ice)

$540m + 80m = 250 + 8000 + 2000$ cal

$620m = 10250$ cal

$\boxed{m = 16.5\,g}$

(8) Energy required $= (100g)\left(1\frac{cal}{g°C}\right)(80°C) = 8000$ cal

$= 8000 \text{ cal} \left(\frac{4.186J}{cal}\right) \approx 33520 J$

$200 \frac{J}{s}(t) = 33520 J$

$t = \frac{33520}{200} = \boxed{168 \text{ sec}} \approx 2.8 \text{ min}$

(9) Energy required $= (4 \times 10^{11} m^3)\left(\frac{1000 Kg}{m^3}\right)\left(4186 \frac{J}{Kg}\right)(1°C)$

$= 1.67 \times 10^{18} J$

$\left(1000 \times 10^6 \frac{J}{s}\right) t = 1.67 \times 10^{18} J$

$t = \boxed{1.67 \times 10^9 \text{ sec}} = 53$ years

(10) Kinetic Energy of Bullet $= \frac{.003 Kg}{2}(300 \text{ m/s})^2$

$= 135 J$

$= 135 J \left(\frac{1 cal}{4.186 J}\right) \approx 32.25$ cal

$m_{ice} L = 32.25$ cal

$m_{ice} = \frac{32.25 \text{ cal}}{80 \text{ cal/g}} \approx \boxed{.403 \text{ grams}}$