Name: Group member names:
Student number:

Physics 157 Tutorial – week of September 17th

In this tutorial, you will get some practice thinking about the thermal expansion of materials and the combined effects of thermal expansion and stress. One of the main goals is to help you learn to solve problems where you need to take into account thermal expansion of different materials – these are important for practical applications and also show up on your homework due next week. **Work in groups of three or four, but hand in your own worksheet,** to be graded for participation credit. You are not required to finish everything on the worksheet. Show your work.

Important formulae:

Linear expansion due to temperature change**: $\Delta L_{th} = \alpha L \Delta T$**

Volume expansion: **$\Delta V = \beta V \Delta T$** **$\beta = 3\alpha$** for solids

Change in length due to changes in stress:

$\Delta \mathbf{Lst} = \frac{1}{Y} L \frac{\Delta F}{A}$ (this is equivalent to the one from last week: $\frac{F}{A} = Y \frac{\Delta L}{L}$)

Net change in length with changes in temperature and stress: **$\Delta L = \Delta L_{th} + \Delta L_{st}$**

Question 1: At 20°C, a spherical steel ball has diameter 1.001cm and sits on a 1.000cm wide circular hole in a copper plate, not quite fitting through. If the ball and plate are heated together, at roughly what temperature will the ball fall through the plate? ($\alpha_{steel} = 1.2 \times 10^{-5}\ K^{-1}$ and $\alpha_{copper} = 1.7 \times 10^{-5}\ K^{-1}$)

See the hint on page 4 if you are stuck. The correct answer is one of the numbers on the back page!

Question 2: To help raise money to buy Mastering Physics codes, you and some friends decide to sell bottles of home-made kombucha in 0.4L glass bottles for $3.50 each at the Totem Park cafeteria. You have 500 full bottles of kombucha stored at 4.0°C. You are originally planning to sell it chilled, but after attending the first few Physics 157 lectures and looking up the thermal expansion coefficients of kombucha ($\beta_{kombucha} = 34.2 \times 10^{-5}\ K^{-1}$) and glass ($\alpha_{glass} = 5.4 \times 10^{-6}\ K^{-1}$) , you realize that if you dump out all the kombucha into a big container and then re-fill bottles in the cafeteria (at 26.0 °C) to sell warm, you'll make more money. If it costs you $0.50 for each extra glass bottle, how much extra money will you make this way?

See the hints on page 4 if you are stuck. The correct answer is one of the numbers on the back page!

Question 3: At a particle accelerator facility, a 16000kg detector is to be installed on top of four aluminum legs, each with cross sectional area $0.001m^2$. The legs are fabricated at 20 ^oC to a height of 0.10000m. After the detector is in place, the scientists adjust the temperature of the legs in order to compensate for the compression due to the weight of the detector. If they would like the final height of the legs to be 0.10000m, what should be the temperature of the legs?

For aluminum, $Y = 7\times10^{10}$, $\alpha = 2.4\times10^{-5}$

See the hints on page 4 if you are stuck. The correct answer is one of the numbers on the back page!

Part b) If the legs need to be kept within the range 0.10000m±0.00005, what range of temperatures are allowable for the aluminum legs?

Hints: wait until you are stuck before using the hints, then try them one at a time.

For each hint, write the missing letters in the blank spaces, in order. For example: putting p,y,c,t,r,l in __h__si__s __uto__ia__ in gives “physics tutorial”

Hint for question 1:

missing letters: t, m, t, r, c, g, w, c, d, r, d, t, r, c

Hint: For a __e__pera__u__e __han__e ΔT, ho__ mu__h does the __iffe__ence in __iame__e__ __hange?

Hint 1 for question 2:

missing letters: h, m, c, v, m, b, l, s, c, g, x, n, g, a

__ow __u__h will the __olu__e of the __ott__e__ __han__e due to the e__pa__sion of __l__ss?

Hint 2 for question 2:

Missing letters: m, n, x, r, b, l, f, x, e, v, l, e, k, b, a

How __a__y e__t__a __ott__es can you __ill with the e__c__ss __o__um__ of __om__uch__?

Hint for question 3:

Missing letters: t, t, c, g, l, g, h, l, g, d, h, g, t, s, c, g, t, p, u

What is the _o_al _han_e in _en_t_ of the _e_s _ue to the c_an_e in s_re_s and the _han_e in _em_erat_re?

Possible correct answers: 240000, 3100, 980, 220, 109, 88, 64, 43, 30, 23, 9, π,0.11, 0.042, 0.0064, 0.00009, 0.000001001, “Despacito”, 0.0000, -8100