

Activity 9: Simultaneous Linear Equations

1. The maximum heart rate (MR) in beats per minute that one should obtain depends on age (A) in years. One fit to the data suggests that MR versus A is linear and is slightly

different for men and women:

$$\text{For men, } MR_m = 202 - 0.55A$$

$$\text{For women, } MR_w = 216 - 1.09A$$

- a. For the units to be consistent, what are the units for:
The y-intercepts, 202 and 216? _____
The slopes, - 0.55 and - 1.09? _____
- b. What is the significance of the negative slope?
- c. At what age would men and women have the same maximum heart rate and what is this heart rate?

d. Graph the equations for MR_m and MR_w versus A to verify your answer to part (c). There are numerous on-line graphing programs that you can use if a graphing calculator is unavailable. Sketch your graphs below.

e. At what age would a man obtain a maximum heart rate of zero? Is this a realistic extrapolation of the equation? Explain.

2. At 12:00 noon, train A passes a landmark, heading east at 70 mi/ hr. At the same time, train B is on a parallel track and is 50 mi east of train A, heading west at 40 mi/ hr. Suppose that we let t represent the time elapsed since 12:00 noon, x represent the position relative to the landmark (origin) and east as our positive direction. Then, for example, when $t = 0$,

$$x_B = 50 \text{ mi.}$$

a. Sketch the scenario, indicating as much as you can with the given information.

- b. Write an equation for the position of train A, x_A , relative to the origin as a function of time t . Make sure to test that your equation makes physical sense, e.g., does $x_A = 0$ at $t = 0$ and also as time goes on?
- c. Write an equation for the position of train B, x_B , relative to the origin as a function of time t .
- d. Use your equations to determine the position and time at which the trains pass each other?
- e. Use your equations to determine the time at which train B is 10 mi to the east of train A. Where is train A at this time?

3. Copper expands proportionally more with temperature than glass. This concept is characterized by the equation $\Delta L =$

$\alpha L_o \Delta T$ where

ΔL is the change in length (expansion or contraction)
 α is the coefficient of linear expansion (material specific)
(for window glass and copper, $\alpha_{\text{glass}} = 11 \times 10^{-6} \text{ } ^\circ\text{C}^{-1}$

and

$$\alpha_{\text{copper}} = 17 \times 10^{-6}$$

$^\circ\text{C}^{-1}$)

L_o is the initial length

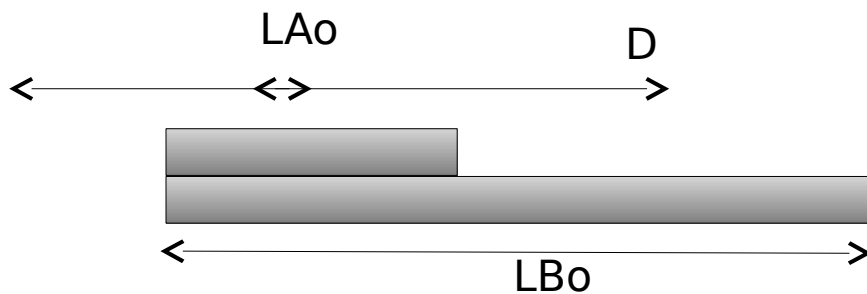
ΔT is the change in temperature

a. Under what conditions can a glass rod expand more than a copper rod?

b. Suppose that a 1 m copper rod is subjected to a temperature increase of 5°C . What increase in temperature would cause a 1 m glass rod to expand by

the same amount? Note that the rods are separate in this case.

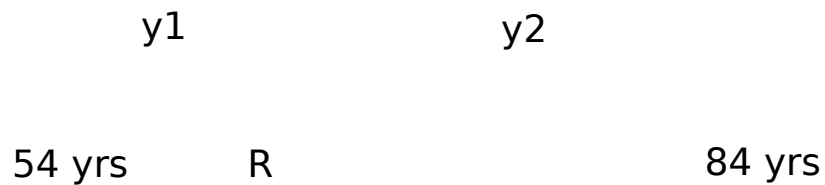
- c. Two bars of different materials are bolted together at the left end. The bars are free to expand on the right end:



Material A is copper and has a length $L_{A0} = 1.00$ m. Material B is glass. If we want the distance between the ends of the rods, D , to be stable (constant) when the temperature fluctuates, what length L_{B0} is needed?

4. The perimeter of a rectangle is 37 inches. The length of this rectangle is 2 inches more than twice its width. First write two equations that relate the length, L and width, W (in inches) with the information given. Then, solve for L and W .
5. A chemistry student has two acidic solutions to mix for her chemistry experiment. Solution 1 is 20% acidic solution 2 is 45% acidic by volume. How many ml of each solution should she mix to obtain 100 ml of a 30% acidic solution? Make a list of your unknowns and the equations that describe the scenario. Then, show your work in solving the equations for your unknowns.

6. Joe is currently 54 years old. His life expectancy is 84 years old and he plans to retire sometime before that. We can represent this situation as follows:



- Write three equations relating y_1 , y_2 and R (the age at which Joe retires).
- Show that if y_1 and y_2 are unknowns, then R can have infinitely many solutions. Then explain logically why this makes sense.

7. Solve these 3 equations for x, y, and z:

$$\begin{aligned}x + y + 2z &= 2 \\3y - 4z &= -5 \\6z &= 3\end{aligned}$$

Why is this set solvable whereas the set in part 6 was not?