

ECE 101: Homework assignment # 2

3. A child's pool is eight feet in diameter and two feet high. It is filled by a garden hose up to a level of one foot. The children complain that it is too cold. Can you heat it up to an acceptable temperature using hot water from the house? How much water would we need to add? (Hint: explicitly state your assumptions; try to follow steps given for problem solving and explain your reasoning)

A SOLUTION:

- 1) "A child's pool is eight feet in diameter and two feet high. It is filled by a garden hose up to a level of one foot. The children complain that it is too cold.

Get an estimate of the temperature of cold water from a tap:

Google search:

<http://www.ask.com/food/average-temperature-cold-tap-water-2bd0ae80e91f5646>

→ 50 degrees Fahrenheit

Let's use degrees Celsius. Use F to C converter

<https://www.google.com/search?q=f+to+c+conversion&ie=utf-8&oe=utf-8>

→ 10 degrees Celsius

- 2) "Can you heat it up to an acceptable temperature using hot water from the house?"

So what would be a comfortable bathing temperature?

Google search:

<http://hypertextbook.com/facts/2005/LouisWilliamTullo.shtml>

or

<http://www.ask.com/beauty-fashion/ideal-temperature-bath-water-85b5c5d348a003>

→ We will use 40 degrees Celsius. (to use round numbers)

- 3) "Can you heat it up to an acceptable temperature using hot water from the house?"

Let's assume we can use boiling water from the house.

→ Thus the house water temperature would be 100 degrees Celsius.

- 4) "A child's pool is eight feet in diameter and two feet high. It is filled by a garden hose up to a level of one foot."

→ The pool has a cylindrical shape. So the volume is $V = \pi r^2 h$.

→ The current volume is $V = \pi \left(\frac{8}{2}\right)^2 1$ (the length units used are feet)

- 5) How do we find the temperature of mixed fluids at different temperatures?

Google search:

<http://physics.stackexchange.com/questions/174251/how-do-i-determine-the-temperature-of-a-fluid-that-was-x-degrees-mixed-with-anot>

We will follow this example and use the formula: $Q = M.C.\Delta(T)$ where M is mass, C is heat capacity, $\Delta(T)$ is the change in temperature and Q is energy required to produce the temperature change.

To change volume to mass we'll use the formula: $M = k.V$ (where k is the appropriate constant, the value of which we won't need to state explicitly).

The energy of the existing water, needed to heat from zero degrees to its current temperature, is:
 $Q_1 = k \pi \left(\frac{8}{2}\right)^2 1 \cdot C \cdot 10$ where C is the heat capacity of water (we don't need the explicit value)

"A child's pool is eight feet in diameter and two feet high."

➔ We can add water to an additional height of 1 foot. Let the fraction of the additional height that needs to be added be given by kx . Thus the energy of the additional water at 100 degrees Celsius is:

$$Q_2 = kx \cdot k \pi \left(\frac{8}{2}\right)^2 1 \cdot C \cdot 100$$

Thus the total energy is:

$$Q = Q_1 + Q_2 = k \pi \left(\frac{8}{2}\right)^2 1 \cdot C \cdot 10 + kx \cdot k \pi \left(\frac{8}{2}\right)^2 1 \cdot C \cdot 100$$

So, as per the example, if we set the final temperature $FT = 40$, the desired combined temperature, then we have:

$$Q = k \pi \left(\frac{8}{2}\right)^2 1 \cdot C \cdot FT + kx \cdot k \pi \left(\frac{8}{2}\right)^2 1 \cdot C \cdot FT$$

which with the relationships above give:

$$k \pi \left(\frac{8}{2}\right)^2 1 \cdot C \cdot 10 + kx \cdot k \pi \left(\frac{8}{2}\right)^2 1 \cdot C \cdot 100 = k \pi \left(\frac{8}{2}\right)^2 1 \cdot C \cdot 40 + kx \cdot k \pi \left(\frac{8}{2}\right)^2 1 \cdot C \cdot 40$$

which leads to

$$10 + kx \cdot 100 = 40 + kx \cdot 40$$

So $kx = 0.5$. This is the answer we're looking for.

So the answers to the two specific questions are:

Question 1: Can you heat it up to an acceptable temperature using hot water from the house?

Answer: Yes

Question 2: How much water would we need to add?

Answer: We could top it up another half a foot with boiling water. The total water height would then be 1.5 feet with a temperature of 40 degrees Celsius.

