

## ME 121: Homework 4

### Group Assignment

1. Build two cascade control circuits using transistors and relays to control the two solenoid valves on your group's fish tank. The circuit should have flyback diodes across the coils of the relays and the solenoid valves. Write an Arduino program to alternate energizing the solenoid valves, holding one open for one second while the other one is closed, and then switch. The pattern should be: valve A on and valve B off, wait one second, valve A off and valve B on, wait one second, valve A on and valve B off, wait one second, ... Be ready to display the operation of this circuit at the start of class.

Bonus 5 points: Install a potentiometer on your circuit board. Use the potentiometer to adjust the delay in the solenoid valve cycle between 0.5 and 2 seconds.

### Individual Assignment

2. A batch of masonry cement is made by mixing three 5-gallon buckets of wet sand with one 70 lb<sub>f</sub> bag of dry masonry mix and 3 gallons of water. The wet sand contains an unknown amount of water.
  - a. If the final batch of "mud" contains 11.3% water by weight when the desired consistency is reached, how many gallons of water did the wet sand use? Assume wet sand and dry sand occupy the same volume. Answer: 1.48 gal
  - b. What is the weight of the final batch of mud?

Be sure to follow the systematic approach presented in class when solving this problem. Remember that learning the correct solution process is just as important as getting the correct answer.

Potentially useful information for this problem:

Specific weight of water = 8.33 lb<sub>f</sub>/gal.

Specific weight of dry sand = 111 lb<sub>f</sub>/ft<sup>3</sup>.

1 gal = 0.1337 ft<sup>3</sup>

3. Use the NPN transistor given to you by your instructor to build a circuit that blinks an LED at one second intervals: one second on, one second off. Build a second LED circuit that takes its power directly from a digital output pin. Blink the second LED at one second intervals exactly out of sync with the LED circuit controlled by the transistor. The diagram to the right displays the on-off pattern of the two circuits.

Transistor circuit 

Direct circuit 

Take a photograph of your breadboard – be sure that all components are clearly visible and in focus. Include the photograph and your Arduino code with the homework you turn in.

4. Go to the Digikey web site ([www.digikey.com](http://www.digikey.com)) and search for a 2N4401 transistor. The search will take you to a web page with many options. Use the filter tool to make the following selections

Manufacturer      ON Semiconductor  
Packaging          Tape & Reel and Tape & Box

Select one of the products that is available in bulk of 5000 items or less. Download the datasheet. From the datasheet and the information on the web site, answer these questions:

- a. What is the per/part cost
  - b. What is the total cost of the minimum quantity?
  - c. What is the maximum current? (Maximum collector current)?
5. Imagine that you are an engineering manager concerned about the budget for parts used by your design and development engineers. Use the following additional data to estimate the true cost of the purchase of the transistors you identified in the previous problem.
- Cost to employ an entry-level engineer: \$95,000 per year
  - Cost to employ an accountant: \$75,000 per year
  - Shipping cost from Digikey: \$15.00

Assume that it took the engineer one hour to identify the part that is compatible with the design and make the purchase request via the internal purchasing request on your company's internal web site. Assume that it took the accountant 1.5 hours to place the order, issue the payment, close the transaction in the annual budget. What is the actual cost per transistor when these business overhead costs are included?