Homework Problems – Week 1

440:127 – Spring 2015 – S. J. Orfanidis

1. End-of-chapter Problem 2.14. Use `'format short e'` to print your results.
2. Problem 2.15. Use `'format short e'` to print your results.
3. Problem 2.18. Use `'format short e'` to print your results. Revert to `'format'` afterwords.
4. The NJ Driver's Manual contains information from which the following table can be obtained of stopping distances and stopping times of cars according to their traveling speeds:

speed (mph)	reaction distance (ft)	braking distance (ft)	total stopping distance (ft)	reaction time (sec)	deceleration (ft/sec^2)	total stopping time (sec)
10	11	6	17	0.75	17.89	1.57
20	22	25	47	0.75	17.25	2.45
30	33	55	88	0.75	17.60	3.25
40	44	105	149	0.75	16.39	4.33
50	55	188	243	0.75	14.29	5.88
60	66	300	366	0.75	12.90	7.57
70	77	455	532	0.75	11.59	9.61

   a. Suppose that the first column of speeds is given as well as the column of reaction times (5th column), and the column of total stopping times (7th column). From this information only, calculate the values shown in columns 2, 3, 4, and 6 of the above table for the reaction distances, braking distances, total stopping distances, and decelerations. Please use vectorized calculations only (no for-loops). Stopping means $v = 0$ and deceleration is negative acceleration.

   b. After reviewing the lecture notes (for week-2) and Section 7.2 of the text on the built-in function `fprintf`, please use `fprintf` to generate your output in a table that looks exactly as the one shown above. The numerical part of the table may be printed using `fprintf` in a loop, or by a single MATLAB command using the vectorized form of `fprintf` (but it's a good idea to figure out how to do both.)

   c. Make a plot of the total stopping distance versus the speed. Use appropriate MATLAB commands to annotate your graph as the one shown below.

   d. Based on the data in the above graph, use MATLAB to estimate the stopping distances for the following intermediate speed values $v_0 = [47, 52, 65]$ mph. On the graph, the data points are connected by straight lines.

$$\left[\textit{Hints: } 1 \text{ mile} = 5280 \text{ ft}, \quad v = v_0 + at, \quad s = v_0 t + \frac{1}{2}at^2 = \frac{(v_0 + at)^2 - v_0^2}{2a} = \frac{v^2 - v_0^2}{2a}\right]$$

5. Problem 2.11. Please use a vectorized calculation (no loops) to compute the amount of CO_2 (start with the vector of mpg's). Moreover, include appropriate MATLAB commands to print the results of your program in the format shown in the table below (you may use a for-loop here). [*Hint:* see the octaves example discussed in class, also note that the largest string in the second column has 21 characters, so use format `%21s` for that column.]

```
 year              model            mpg         CO2
-------------------------------------------------------
 2008           smart for two     37 mpg     6291.89 lbs
 2008             civic coupe     29 mpg     8027.59 lbs
 2008            civic hybrid     43 mpg     5413.95 lbs
 2008        chevrolet cobalt     30 mpg     7760.00 lbs
 2008   toyota prius (hybrid)     46 mpg     5060.87 lbs
 2008            toyota yaris     32 mpg     7275.00 lbs
-------------------------------------------------------
```

6. *Matched Loads.* An electric load (e.g., appliance, computer, etc.) connected to an electric power source (e.g., wall outlet, battery, etc.) appears to the power source as a resistance (impedance, more generally). Using Ohm's and Kirchhoff's laws, it can be shown that the power delivered to and consumed by a load is given by:

$$P = \frac{V_0^2 R}{(R_0 + R)^2} \tag{1}$$

where R is the load resistance, and V_0, R_0 are the voltage of the generator and its internal resistance. The *maximum power transfer theorem* states that maximum power is delivered to the load when the load resistance matches that of the generator, that is, when $R = R_0$.

a. For the following values $V_0 = 100$ volts, $R_0 = 50$ ohm, calculate the maximum power P that can be delivered to a matched load (the power will be in units of Watts if the voltage and resistances are in units of volts and ohms, respectively).

b. Using the **linspace** function, generate a vector of 601 resistance values in the interval $0 \le R \le 300$ ohms, and using a *vectorized* version of Eq. (1), calculate the corresponding 601 values of P in units of Watts. Make a plot of P versus R, and indicate on the graph the point of maximum power transfer.

c. Add appropriate MATLAB commands to reproduce all the graph annotations shown below, i.e., title, axis labels, axis limits, tickmarks, grid, and legends. [*Hint:* see the octaves example].

Note: The proof of the maximum power transfer theorem is straightforward. If you know calculus, you may compute the derivative dP/dR and set it equal to zero to obtain $R = R_0$. Alternatively, it's a matter of algebra to show the following identity in R:

$$P = \frac{V_0^2 R}{(R_0 + R)^2} = \frac{V_0^2}{4R_0} \cdot \left[1 - \frac{(R - R_0)^2}{(R + R_0)^2} \right]$$

which shows that for all values of R,

$$P \leq \frac{V_0^2}{4R_0}$$

with equality reached at $R = R_0$.