Sprinkler Design Project

ME 575

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Sprinkler Design Problem

You have been hired by the premier golf course in town. Your boss has given you a $1250 budget to make a very simple sprinkler system for the course's main fairway. In order to attract the big names, your boss would like you to design the longest possible fairway that will be watered under this budget. You have a pool of standing water from which to draw. Additionally, the pipe that your boss would like to use is 0.2 $ / ft. You have 2 sprinkler options and 4 pump options with the specifications given below:

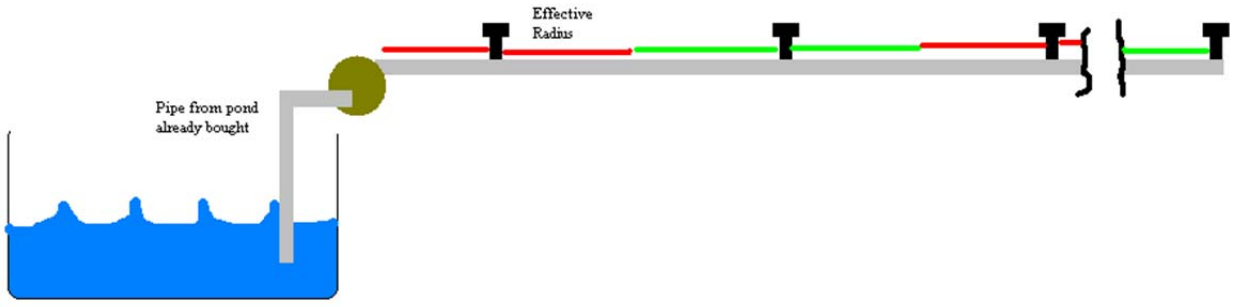
	Sprinkler 1	**Sprinkler 2**
Price ($ / head)	3	7
Effective Radius of Spray (ft)	3	9
Flow Rate Required ($ft^3\ s^{-1}$)	0.05	0.1
Nozzle Area (ft)	0.01	0.01

	Pump 1	**Pump 2**	**Pump 3**	**Pump 4**
Power ($lb\ ft^2\ s^{-3}$)	50	100	150	200
Price ($ / pump)	75.00	119.61	145.71	164.23

Part 1 – Assuming all variables are continuous, graph the feasible space with number of sprinkler 1 and sprinkler 2 as the axes. Show the inequality constraints and pipe length contours with the optimum point labeled and the feasible space shaded.

Part 2 – Setting the number of sprinkler heads, number of pumps, and pump types as integer values, redo the optimization. (Don't worry about graphing this one) Compare this solution with the continuous solution. What happened to the total number of sprinkler heads? Why do you think this happened?

Report the pipe length, number of pumps, number of each sprinkler, pump type, and unused money for each part.



(See hints on the next page)

Hints:

- Think of the system as an electrical circuit where the pressure drop across each head is constant, but the flow rate through each head may not be, i.e. the heads are in parallel.
- Friction in pipe is negligible
- You need to use at least one pump
- The energy balance for this system should be of the form:

$$\frac{W_{pumps}}{\rho Q} = \frac{\Delta v^2}{2} + \frac{\Delta P}{\rho} + g\Delta z$$

  where ρ is the density of water, Q is the total volumetric flow rate, v is velocity, P is pressure, g is the gravity constant, and z is height.
- Assume the height difference from the pond to the fairway is negligible.
- Density of water = 62.3 lb ft^{-3}
- Try correlating pump type and price using a natural log function.