Linear Programming Diet Problem

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Image from iStock.com

$ and Nutrients		Unit Contribution				Requirements
		limestone	corn	soybean		
calcium(kg/kg)		0.38	0.001	0.002	>=0.008,<=0.012	
protein(kg/kg)		0	0.09	0.5	>=0.22	
fiber(kg/kg)		0	0.02	0.08	<=0.05	
price($/kg)		0.1	0.2	0.4		

- There is an Agricultural mill that produces livestock feed by combining limestone, corn and soybeans. They want us to help them optimize their feed mix.
- Given the information from this spread sheet (these values may not reflect reality), we need to find a way to minimize the cost of the feed mix per kg while also meeting the nutrition requirements of the livestock.
- From the table we see limestone costs 10 cents/kg and has 0.38 kg of calcium per kg. Also, each kg of feed requires between .008 and .012 kgs of calcium inclusive.
- First, we will create a formulation for the problem, and then we will use the optimizatoion package, PuLP to calculate our answers.
- The variables are: xl=kgs of limestone, xc=kgs of corn, xs=kgs of soybeans

objective function

$$\text{Minimize: } 0.1xl + 0.2xc + 0.4xs$$

subject to

$$\begin{gathered}
0.008 \le 0.38xl + 0.001xc + 0.002xs \le 0.012 \\
0.22 \le 0.09xc + 0.5xs \le 1 \\
0 \le 0.02xc + 0.08xs \le 0.05 \\
xl + xc + xs = 1 \\
0 \le xl \le 1 \\
0 \le xc \le 1 \\
0 \le xs \le 1
\end{gathered}$$

In [11]:
```python
from pulp import*
```

In [12]:
```python
prob = LpProblem("Feed_Mix", LpMinimize)

xl = LpVariable("xl", lowBound=0)                    # xl >=0
xc = LpVariable("xc", lowBound=0)                    # xc >= 0
xs = LpVariable("xs", lowBound=0)                    # xs >= 0

prob += 0.1*xl+0.2*xc+0.4*xs                         # objective function in $

prob += xl+xc+xs==1                                  # Constraint: components add up to 1

prob += 0.008<= 0.38*xl+0.001*xc+0.002*xs            # Constraint: calcium
prob += 0.38*xl+0.001*xc+0.002*xs<=0.012

prob += 0.22<=0.09*xc+0.5*xs                         # Constraint: protein
prob += 0.09*xc+0.5*xs<=1

prob += 0<=0.02*xc+0.08*xs                           # Constraint: fiber
prob += 0.02*xc+0.08*xs<=0.05

prob += xl<=1                                        # All nutrients are between 0 and 1 kg
prob += xc<=1
prob += xs<=1
```

In [13]:
```python
solve = prob.solve();  # solve with the default solver
```

In [14]:
```python
value(xl), value(xc), value(xs), value(prob.objective)
```

Out[14]:
```
(0.028170826, 0.64857216, 0.32325701, 0.2618343186)
```

So, our optimal solution is approximately 0.0282 kg of limestone, 0.649 kg of corn and 0.323 kg of soybeans at a cost of 26 cents per kg of feed.