Homework Two: Linear Programs

Question One

Story Problem : Farmer Jane owns 45 acres of land. She is going to plant each with wheat or corn. Each acre planted with wheat yields 230 profit; each with corn yields 190 profit. The labor and fertilizer used for each acre are given in the table below. 100 workers and 130 tons of fertilizer areavailable.

Expanded solution

Problem Data

In [1]:
```
using JuMP, Clp

m = Model(solver = ClpSolver())

@variable(m, wheat >= 0)                  # wheat
@variable(m, corn >= 0)                   # corn

@constraint(m, wheat + corn <= 45)        # total land to work on
@constraint(m, 3wheat + 2corn <= 100)     # total number of labor
@constraint(m, 2wheat + 4corn <= 130)     # total amount of fertilizer

@objective(m, Max, 230wheat + 190corn)    # maximize profit

m
```

Out[1]:

$$\begin{aligned} \max \quad & 230 wheat + 190 corn \\ \text{Subject to} \quad & wheat + corn \leq 45 \\ & 3 wheat + 2 corn \leq 100 \\ & 2 wheat + 4 corn \leq 130 \\ & wheat \geq 0 \\ & corn \geq 0 \end{aligned}$$

Problem Model

In [2]:
```
println(m)
status = solve(m)
println(status)
```

```
Max 230 wheat + 190 corn
Subject to
 wheat + corn ≤ 45
 3 wheat + 2 corn ≤ 100
 2 wheat + 4 corn ≤ 130
 wheat ≥ 0
 corn ≥ 0

Optimal
```

In [3]:

```
using JuMP
println("Acres of Wheat:" , getvalue(wheat))
println("Acres of Corn: " , getvalue(corn))

profit = (230 * wheat) + (190 * corn)
println("Total profit: \$", getvalue(profit))
```

```
Acres of Wheat:17.499999999999993
Acres of Corn: 23.750000000000004
Total profit: $8537.5
```

The ideal solution, and one I would recommend, is to cover 17.5 acres with Wheat and 23.75 acres of Corn. This will produce the optimal profit (highest return) for Farmer Jane.

2b. Solve in a different method.

In [1]:

```
# the types of produce
product = [:wheat, :corn]

# fertilizer required for each type of prodcut
fert   = Dict( :wheat => 2, :corn => 4)

# labor required for each type of product
labor = Dict( :wheat => 3, :corn => 2)

# acres required for each crop --- not sure if I actually need this, do not think
acres = Dict( :wheat => 1, :corn => 1)

# profit made for each product
profit = Dict( :wheat => 230, :corn => 190)

# quantities in stock for each ingredient
num_fert     = 130
num_labor    = 100
num_acres    = 45
```

In [2]:
```
using JuMP, Clp
m = Model(solver = ClpSolver())

@variable(m, crop[product] >= 0 )    # "crop" is a dictionary indexed over produc

@expression(m, tot_labor,   sum(crop[i] * labor[i]   for i in product) )
@expression(m, tot_fert,    sum(crop[i] * fert[i]    for i in product) )
@expression(m, tot_acres,   sum(crop[i] * acres[i]    for i in product) )
@expression(m, tot_profit,  sum(crop[i] * profit[i]  for i in product) )

@constraint(m, crop[:wheat] <= num_acres )      # maximum number of wheat that ca
@constraint(m, crop[:corn]  <= num_acres )      # maximum number of corn that can
@constraint(m, tot_labor    <= num_labor )      # maximum number of labor needed
@constraint(m, tot_fert     <= num_fert )       # maximum number of fertilizer ne

@objective(m, Max, tot_profit)

solve(m)
println(getvalue(crop))
println("Total profit will be \$", getvalue(tot_profit))
println("Fertilizer needed: ", getvalue(tot_fert))
println("Acres used: ", getvalue(tot_acres))
println("People needed: ", getvalue(tot_labor))
```

```
crop: 1 dimensions:
[wheat] = 17.499999999999993
[ corn] = 23.750000000000004
Total profit will be $8537.5
Fertilizer needed: 130.0
Acres used: 41.25
People needed: 99.99999999999999
```

As we can see here, the two values are identical. Therefore, I feel confident saying that I have found the correct answer. The recommendation remains to cover 17.5 acres with Wheat, and 23.75 acres of Corn.

In [ ]: