It is a Non Linear Problem

In [ ]:
```
using JuMP
import Ipopt
```

In [ ]:
```
model = Model(Ipopt.Optimizer) # Using Non Linear solver
```

```
A JuMP Model
Feasibility problem with:
Variables: 0
Model mode: AUTOMATIC
CachingOptimizer state: EMPTY_OPTIMIZER
Solver name: Ipopt
```

In [ ]:
```
@variable(model, x, lower_bound = 0, upper_bound = 80) # Fixing minimum and maxi
```

$$x$$

In [ ]:
```
h = 50
```

```
50
```

In [ ]:
```
g = 9.81
```

```
9.81
```

In [ ]:
```
v = 90
```

```
90
```

Time to reach peak height :

$$t_1 = \frac{v * sin(\theta)}{g}$$

In [ ]:
```
t1 = @NLexpression(model, v * sind(x) / g)
```

```
subexpression[1]: (90.0 * sind(x)) / 9.81
```

Time to reach ground from peak height:

$$t_2 = \sqrt{\frac{2H}{g}}$$

where H is the peak height

$$H = h + \frac{v^2 * sin^2(\theta)}{2g}$$

So

$$t_2 = \sqrt{\frac{2h}{g} + (\frac{v * sin(\theta)}{g})^2}$$

In [ ]:
```
t2 = @NLexpression(model, sqrt(2 * h / g + (v * sind(x) / g)^2))
```

subexpression[2]: sqrt((2.0 * 50.0) / 9.81 + ((90.0 * sind(x)) / 9.81) ^ {2.0})

Thus total time will be:

$$t_1 + t_2$$

In [ ]:
```
total_time = @NLexpression(model, t1 + t2)
```

subexpression[3]: subexpression_{1} + subexpression_{2}

In [ ]:
```
total_range = @NLexpression(model, total_time * v * cosd(x))
```

subexpression[4]: subexpression_{3} * 90.0 * cosd(x)

In [ ]:
```
@NLobjective(model, Max, total_range)
```

In [ ]:
```
@show model
```

```
model = A JuMP Model
Maximization problem with:
Variable: 1
Objective function type: Nonlinear
`VariableRef`-in-`MathOptInterface.GreaterThan{Float64}`: 1 constraint
`VariableRef`-in-`MathOptInterface.LessThan{Float64}`: 1 constraint
Model mode: AUTOMATIC
CachingOptimizer state: EMPTY_OPTIMIZER
Solver name: Ipopt
Names registered in the model: x
A JuMP Model
Maximization problem with:
Variable: 1
Objective function type: Nonlinear
`VariableRef`-in-`MathOptInterface.GreaterThan{Float64}`: 1 constraint
`VariableRef`-in-`MathOptInterface.LessThan{Float64}`: 1 constraint
Model mode: AUTOMATIC
CachingOptimizer state: EMPTY_OPTIMIZER
Solver name: Ipopt
Names registered in the model: x
```

In [ ]:
```
optimize!(model)
```

```
This is Ipopt version 3.14.13, running with linear solver MUMPS 5.6.1.

Number of nonzeros in equality constraint Jacobian...:        0
Number of nonzeros in inequality constraint Jacobian.:        0
Number of nonzeros in Lagrangian Hessian.............:        1

Total number of variables............................:        1
                     variables with only lower bounds:        0
                variables with lower and upper bounds:        1
                     variables with only upper bounds:        0
Total number of equality constraints.................:        0
Total number of inequality constraints...............:        0
        inequality constraints with only lower bounds:        0
   inequality constraints with lower and upper bounds:        0
        inequality constraints with only upper bounds:        0

iter    objective    inf_pr   inf_du lg(mu)  ||d||  lg(rg) alpha_du alpha_pr  ls
   0  2.8749203e+02 0.00e+00 1.44e+01  -1.0 0.00e+00    -  0.00e+00 0.00e+00   0
   1  2.9105335e+02 0.00e+00 1.36e+01  -1.0 2.46e-01    -  6.36e-02 1.00e+00f  1
   2  8.4789227e+02 0.00e+00 5.98e+00  -1.0 3.56e+01   0.0 9.79e-03 1.00e+00f  1
   3  8.7423639e+02 0.00e+00 3.72e-01  -1.0 7.74e+00    -  1.00e+00 1.00e+00f  1
   4  8.7425946e+02 0.00e+00 1.17e-04  -1.0 2.19e-01    -  1.00e+00 1.00e+00f  1
   5  8.7425946e+02 0.00e+00 1.33e-09  -2.5 7.21e-04    -  1.00e+00 1.00e+00f  1
   6  8.7425946e+02 0.00e+00 3.57e-13  -3.8 1.18e-05    -  1.00e+00 1.00e+00f  1
   7  8.7425946e+02 0.00e+00 9.95e-16  -5.7 6.60e-07    -  1.00e+00 1.00e+00f  1
   8  8.7425946e+02 0.00e+00 2.45e-15  -8.6 8.18e-09    -  1.00e+00 1.00e+00f  1

Number of Iterations....: 8

                                   (scaled)                 (unscaled)
Objective...............:  -8.7425945913405087e+02    8.7425945913405087e+02
Dual infeasibility......:   2.4455532738497097e-15    2.4455532738497097e-15
Constraint violation....:   0.0000000000000000e+00    0.0000000000000000e+00
Variable bound violation:   0.0000000000000000e+00    0.0000000000000000e+00
Complementarity.........:   2.5059039712143006e-09    2.5059039712143006e-09
Overall NLP error.......:   2.5059039712143006e-09    2.5059039712143006e-09


Number of objective function evaluations             = 9
Number of objective gradient evaluations             = 9
Number of equality constraint evaluations            = 0
Number of inequality constraint evaluations          = 0
Number of equality constraint Jacobian evaluations   = 0
Number of inequality constraint Jacobian evaluations = 0
Number of Lagrangian Hessian evaluations             = 8
Total seconds in IPOPT                               = 0.004

EXIT: Optimal Solution Found.
```

In [ ]:
```
@show value.(x) # Gives out value of x for which range is maximum.
```

```
value.(x) = 43.363373916696226
43.363373916696226
```

In [ ]:
```
@show objective_value(model) # Gives out maximum range.
```

```
objective_value(model) = 874.2594591340509
874.2594591340509
```