Question **1**

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Maria wants to bake artisan sourdough bread for her sister's wedding. She estimates that she will need to bake 25 loaves of bread. Unfortunately, she has started too late with making the dough, so that she does not have enough time to follow her original recipe's rising time of 72 h. In order to shorten the rising time, she has two possibilities: She can add more sourdough starter to the dough, where for one loaf, each additional 50 g of starter will reduce the rising time by 3 h. Or she can speed up the bread rise by adding industrial yeast, but since yeast bread is less flavourful and dries out more quickly, she wants to use as little yeast as possible. For each 0.1 g of yeast she adds to the dough of one bread, the rising time will be reduced by 1 h. If she wants to finish the bread in time, the rising time can be at most 40 h. Also note that she only has 500 g of surplus starter in total for all 25 loaves.

How much yeast does she need to use for each loaf of bread in order to have the bread ready in time?

Formulate a corresponding LP and solve with Excel Solver or Julia. Which of the following is the optimal solution?

- ☐ a. 30.8g of additional yeast.
- ☑ b. 3.08g of additional yeast. ✓
- ☐ c. No additional yeast!
- ☐ d. 0.2g of additional yeast.

Check

Your answer is correct.

You have correctly selected 1.

Correct

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original recipe's rising time of 72 h.

If she wants to finish the bread in time, the rising time can be at most 40 h
=> speed up time >= 72 -40 = 32
t >= 32

Also note that she only has 500 g of surplus starter in total for all 25 loaves.

=> First constraint: s <= 500/25 = 20

she can speed up the bread rise by adding industrial yeast, but since yeast bread is less flavourful and dries out more quickly, she wants to use as little yeast as possible.

=> Goal: min y

For each 0.1 g of yeast she adds to the dough of one bread, the rising time will be reduced by 1 h => time reduced by y g of yeast: 10y

She can add more sourdough starter to the dough, where for one loaf, each additional 50 g of starter will reduce the rising time by 3 h => Time reduced by s g of starter: 0.06s

=> **Second constraint: 10y + 0.06s >= t = 32**

How much yeast does she need to use for each loaf of bread in order to have the bread ready in time? **=> find y**

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Problem 1:
a) Solve the optimization problem
        min .       y
        s.t.    x      <= 500
              0.06x + 10 y ≥ 32
                x + y <= 25
```

```
using JuMP, Cbc # modelling language and solver
d1 = Model(with_optimizer(Cbc.Optimizer,logLevel = 0)) # create the model, select the solver
@variable(d1, x[1:2] >= 0) #creates the non-negative variables x1 and x2
@constraint(d1, x[1] <= 20) # constraint 1
@constraint(d1, 0.06*x[1] + 10 * x[2] >= 32) # constraint 2
# @constraint(d1, x[1] + x[2] <= 25) # constraint 2
@objective(d1, Min, x[2]) # declare the objective function
optimize!(d1) # solve the optimization problem

# printing out the solution
x_value = value.(x)
print("Optimal values: $(x_value), \nOptimal objective: $(objective_value(d1))\n")
```

```
Optimal values: [20.0, 3.08],
Optimal objective: 3.08
Presolve 0 (-2) rows, 0 (-2) columns and 0 (-3) elements
Optimal - objective value 3.08
After Postsolve, objective 3.08, infeasibilities - dual 0 (0), primal 0 (0)
Optimal objective 3.08 - 0 iterations time 0.002, Presolve 0.00
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Question **2**

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For each of the given directions, determine the z which is an objective of a linear program whose steepest ascent is in this direction.

1. Direction $[5, 3]^\top$: (i) $z = 5x_1$ (ii) $z = 3x_2$ (iii) $z = 3x_1 + 5x_2$ (iv) $z = 5x_1 + 3x_2$
2. Direction $[1, 6]^\top$: (i) $z = 6x_1 + 1x_2$ (ii) $z = -x_1 - 6x_2$ (iii) $z = 1x_1 - 6x_2$ (iv) $z = 2.5x_1 + 15x_2$
3. Direction $[-1, 1]^\top$: (i) $z = x_1 - x_2$ (ii) $z = x_1 + x_2$ (iii) $z = -x_1 - x_2$ (iv) $z = -x_1 + x_2$

- [ ] a. 1: (i)
- [ ] b. 1: (ii)
- [x] c. 1: (iv) ✓
- [x] d. 2: (iv) ✓
- [ ] e. 2: (ii)
- [x] f. 3: (iv) ✓
- [ ] g. 3: (ii)
- [ ] h. 3: (iii)
- [ ] i. 2: (i)
- [ ] j. 2: (iii)
- [ ] k. 1: (iii)
- [ ] l. 3: (i)

Check

Your answer is correct.

You have correctly selected 3.

Correct

Marks for this submission: 1.00/1.00.