Question **1**

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min $3x_1 - 2x_2$

such that

$-x_1 + x_2 \leq 5$

$-4x_1 + 5x_2 \leq 16$

$x_1 \leq 0$

$x_2 \geq 0$

Transform the linear problem above into the standard form, reformulate the problem as maximization and solve it using the tabular Simplex algorithm.

(a) Which of the following options corresponds to the row of the slack variable which is a basic variable in the final table? s_1, s_2 refer to the slack variables.

(b) What is the value of x_1 at the optimum?

- [ ] a. -5
- [ ] b. -16
- [x] c. $-\frac{1}{4}x_2 + s_1 - \frac{1}{4}s_2 = 1$
- [ ] d. 4
- [ ] e. $\frac{1}{4}x_2 + s_1 + \frac{5}{4}s_2 = 1$
- [ ] f. $\frac{1}{4}x_1 + s_2 = 2$
- [x] g. -4
- [ ] h. $x_1 + \frac{5}{4}x_2 + \frac{1}{4}s_2 = 4$

max $3x_1' + 2x_2$

s.t. $x_1' + x_2 \leq 5$

$4x_1' + 5x_2 \leq 16$

$x_1' \geq 0, x_2 \geq 0$

with $x_1' = -x_1$

basic	x_1'	x_2	s_1	s_2	Sol
z	-3	-2	0	0	0
s_1	1	1	1	0	5
s_2	4	5	0	1	16

$5/1 = 5$

$16/4 = 4$

=>

basic	x_1'	x_2	s_1	s_2	Sol
z	0	7/4	0	3/4	12
s_1	0	-1/4	1	-1/4	1
x_1	1	5/4	0	1/4	$\boxed{4}$

origin: $x_1' = -x_1$

$\Rightarrow x_1 = -4$

Question **2**

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Solve the following LP-problem using the 2-phase method. When using the 2-phase method, reformulate the minimization of the artificial objective function to maximization ($\textbf{min. } z_1 + z_2 \rightarrow \textbf{max. } - z_1 - z_2$).

max $-x_1 + x_2$

such that

$x_1 + x_2 \geq 1,$

$3x_1 + 2x_2 = 6,$

$x_1, x_2 \geq 0$

(a) Which two variables are the basic variables in the final tableau of the 1st phase? s_i refer to the slack variables and z_i to the variables in the artificial objective function.

(b) What are the values of x_1, x_2 and s_1 in the final Simplex tableau at the end of the second phase?

- [ ] a. z_1, s_2
- [ ] b. s_2, x_2
- [ ] c. s_2, x_1
- [ ] d. $x_1 = -3, x_2 = 0, s_1 = -3$
- [x] e. s_1, x_1
- [ ] f. $x_1 = 1, x_2 = 1, s_1 = 0$
- [x] g. $x_1 = 0, x_2 = 3, s_1 = 2$
- [ ] h. $x_1 = 3, x_2 = 0, s_1 = 0$

max $-x_1 + x_2$
$x_1 + x_2 \geq 1$
$3x_1 + 2x_2 = 6$
$x_1, x_2 \geq 0$

$\Rightarrow$ max $-x_1 + x_2$
$x_1 + x_2 - s_1 = 1$
$3x_1 + 2x_2 = 6$
$x_1, x_2, s_1 \geq 0$

$\Rightarrow$ min $r_1 + r_2$ or max $-r_1 - r_2$
$x_1 + x_2 - s_1 + r_1 = 1$
$3x_1 + 2x_2 + r_2 = 6$
$r_1, r_2 \geq 0$

basic sol $x_1 = x_2 = 0$, $s_1 = -1$ not correct

First phase

	x_1	x_2	r_1	r_2	s_1	Sol.	Operation
z	-0	0	-1	1	0	0	$\rightarrow = r_1 + r_2$
r_1	1	1	1	0	-1	1	
r_2	3	2	0	1	0	6	

$\Rightarrow$

	x_1	x_2	r_1	r_2	s_1	Sol	ratio
z	-4	-3	0	0	1	-7	
r_1	1	1	1	0	-1	1	1/1 = 1
r_2	3	2	0	1	0	6	6/3 = 2

$\Rightarrow$

	x_1	x_2	r_1	r_2	s_1	Sol
z	0	1	4	0	-3	-3
r_1	1	1	1	0	-1	1
r_2	0	-1	-3	1	$\boxed{3}$	3

$\Rightarrow$

	x_1	x_2	r_1	r_2	s_1	Sol.
z	0	0	$\boxed{1}$	$\boxed{1}$	0	$\boxed{0}$
r_1	1	2/3	0	1/3	0	2
r_2	0	-1/3	-1	1/3	1	1

basic feasible solution exists

Second phase

	x_1	x_2	s_1	Sol
z	1	-1	0	0
x_1	1	2/3	0	2
s_1	0	-1/3	1	1

$\Rightarrow$

	x_1	x_2	s_1	Sol
z	2.5	0	0	3
x_2	1.5	3	0	3
s_1	0.5	0	1	2

$\Rightarrow$ Optimal sol: $z = 3$ at $s_1 = 2$, $x_2 = 3 \Rightarrow x_1 = 0$

$\Rightarrow (x_1, x_2) = (0, 3)$