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## *Simplex Method Exam Questions (Edexcel)*

**Q1.**

A garden centre makes hanging baskets to sell to its customers. Three types of hanging basket are made, *Sunshine*, *Drama* and *Peaceful*. The plants used are categorised as *Impact*, *Flowering* or *Trailing*.

Each *Sunshine* basket contains 2 *Impact* plants, 4 *Flowering* plants and 3 *Trailing* plants.
Each *Drama* basket contains 3 *Impact* plants, 2 *Flowering* plants and 4 *Trailing* plants.
Each *Peaceful* basket contains 1 *Impact* plant, 3 *Flowering* plants and 2 *Trailing* plants.

The garden centre can use at most 80 *Impact* plants, at most 140 *Flowering* plants and at most 96 *Trailing* plants each day.

The profit on *Sunshine*, *Drama* and *Peaceful* baskets are £12, £20 and £16 respectively.
The garden centre wishes to maximise its profit.

Let $x$, $y$ and $z$ be the number of *Sunshine*, *Drama* and *Peaceful* baskets respectively, produced each day.

(a) Formulate this situation as a linear programming problem, giving your constraints as inequalities.

**(5)**

(b) State the further restriction that applies to the values of $x$, $y$ and $z$ in this context.

**(1)**

The Simplex algorithm is used to solve this problem. After one iteration, the tableau is

| b.v. | $x$ | $y$ | $z$ | $r$ | $s$ | $t$ | Value |
|---|---|---|---|---|---|---|---|
| $r$ | $-\frac{1}{4}$ | 0 | $-\frac{1}{2}$ | 1 | 0 | $-\frac{3}{4}$ | 8 |
| $s$ | $\frac{5}{2}$ | 0 | 2 | 0 | 1 | $-\frac{1}{2}$ | 92 |
| $y$ | $\frac{3}{4}$ | 1 | $\frac{1}{2}$ | 0 | 0 | $\frac{1}{4}$ | 24 |
| $P$ | 3 | 0 | $-6$ | 0 | 0 | 5 | 480 |

(c) State the variable that was increased in the first iteration. Justify your answer.

**(2)**

(d) Determine how many plants in total are being used after only one iteration of the Simplex algorithm.

**(1)**

(e) Explain why for a second iteration of the Simplex algorithm the 2 in the $z$ column is the pivot value.

**(2)**

After a second iteration, the tableau is

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| b.v. | $x$ | $y$ | $z$ | $r$ | $s$ | $t$ | Value |
|---|---|---|---|---|---|---|---|
| $r$ | $\frac{3}{8}$ | 0 | 0 | 1 | $\frac{1}{4}$ | $-\frac{7}{8}$ | 31 |
| $z$ | $\frac{5}{4}$ | 0 | 1 | 0 | $\frac{1}{2}$ | $-\frac{1}{4}$ | 46 |
| $y$ | $\frac{1}{8}$ | 1 | 0 | 0 | $-\frac{1}{4}$ | $\frac{3}{8}$ | 1 |
| $P$ | $\frac{21}{2}$ | 0 | 0 | 0 | 3 | $\frac{7}{2}$ | 756 |

(f) Use algebra to explain why this tableau is optimal.

**(1)**

(g) State the optimal number of each type of basket that should be made.

**(1)**

The manager of the garden centre is able to increase the number of *Impact* plants available each day from 80 to 100. She wants to know if this would increase her profit.

(h) Use your final tableau to determine the effect of this increase. (You should not carry out any further calculations.)

**(2)**

**(Total for question = 15 marks)**

**(Q05 9FM0/3D-4D, Specimen papers )**

**Q2.**

| basic variable | $x$ | $y$ | $z$ | $r$ | $s$ | $t$ | Value |
|---|---|---|---|---|---|---|---|
| $r$ | 12 | 4 | 5 | 1 | 0 | 0 | 246 |
| $s$ | 9 | 6 | 3 | 0 | 1 | 0 | 153 |
| $t$ | 5 | 2 | -2 | 0 | 0 | 1 | 171 |
| $P$ | -2 | -4 | -3 | 0 | 0 | 0 | 0 |

The tableau below is the initial tableau for a linear programming problem in $x$, $y$ and $z$. The objective is to maximise the profit, $P$.

Using the information in the tableau, write down

(a) the objective function,

**(2)**

(b) the three constraints as inequalities with integer coefficients.

**(3)**

Taking the most negative number in the profit row to indicate the pivot column at each stage,

(c) solve this linear programming problem. Make your method clear by stating the row operations you use.

**(9)**

(d) State the final values of the objective function and each variable.

**(3)**

One of the constraints is not at capacity.

(e) Explain how it can be identified.

**(1)**

**(Total 18 marks)**

**(Q05 6689/01, June 2007)**

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**Q3.**

| Basic variable | $x$ | $y$ | $z$ | $r$ | $s$ | $t$ | Value |
|---|---|---|---|---|---|---|---|
| $r$ | 15 | −2 | 3 | 1 | 0 | 0 | 180 |
| $s$ | 10 | 1 | 1 | 0 | 1 | 0 | 80 |
| $t$ | 1 | 6 | −2 | 0 | 0 | 1 | 100 |
| $P$ | −1 | −2 | −5 | 0 | 0 | 0 | 0 |

The tableau below is the initial tableau for a three-variable linear programming problem in $x$, $y$ and $z$. The objective is to maximise the profit, $P$.

(a) Using the information in the tableau, write down

(i) the objective function,
(ii) the three constraints as inequalities.

**(3)**

(b) Taking the most negative number in the profit row to indicate the pivot column at each stage, solve this linear programming problem. Make your method clear by stating the row operations you use.

**(8)**

(c) State the final values of the objective function and each variable.

**(2)**

**(Total for question = 13 marks)**

**(Q08 6690/01, June 2017)**

**Q4.**

| Basic Variable | $x$ | $y$ | $z$ | $r$ | $s$ | $t$ | Value |
|---|---|---|---|---|---|---|---|
| $r$ | 0 | 5 | 2 | 1 | −3 | 0 | 10 |
| $x$ | 1 | 2 | 3 | 0 | 1 | 0 | 18 |
| $t$ | 0 | 1 | −1 | 0 | 4 | 1 | 3 |
| $P$ | 0 | 3 | −4 | 0 | 1 | 0 | 7 |

A three-variable linear programming problem in $x$, $y$ and $z$ is to be solved. The objective is to maximise the profit, $P$. The following tableau is obtained after the first iteration.

(a) State which variable was increased first, giving a reason for your answer.

**(1)**

(b) Perform **one** complete iteration of the simplex algorithm, to obtain a new tableau, T. Make your method clear by stating the row operations you use.

**(5)**

(c) Write down the profit equation given by T.

**(1)**

(d) State whether T is optimal. You must use your answer to (c) to justify your answer.

**(2)**

**(Total for question = 9 marks)**

**(Q09 6690/01, June 2016)**

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**Q5.**
The tableau below is the initial tableau for a linear programming problem in $x$, $y$ and $z$. The objective is to maximise the profit, $P$.

| Basic variable | $x$ | $y$ | $z$ | $r$ | $s$ | $t$ | Value |
|---|---|---|---|---|---|---|---|
| $r$ | 2 | −4 | 1 | 1 | 0 | 0 | 15 |
| $s$ | 4 | 2 | −8 | 0 | 1 | 0 | 20 |
| $t$ | 1 | −1 | 4 | 0 | 0 | 1 | 8 |
| $P$ | −3 | 2 | 7 | 0 | 0 | 0 | 0 |

(a) Perform **one** iteration of the Simplex algorithm to obtain a new tableau, $T$. State the row operations you use.

**(5)**

(b) Write down the profit equation given by $T$ and state the current values of the slack variables.

**(2)**

**(Total for question = 7 marks)**

**(Q06 6690/01, June 2015)**

**Q6.**
The tableau below is the initial tableau for a three-variable linear programming problem in $x$, $y$ and $z$. The objective is to maximise the profit, $P$.

| Basic Variable | $x$ | $y$ | $z$ | $r$ | $s$ | $t$ | Value |
|---|---|---|---|---|---|---|---|
| $r$ | 4 | 3 | $\frac{5}{2}$ | 1 | 0 | 0 | 50 |
| $s$ | 1 | 2 | 1 | 0 | 1 | 0 | 30 |
| $t$ | 0 | 5 | 1 | 0 | 0 | 1 | 80 |
| $P$ | −25 | −40 | −35 | 0 | 0 | 0 | 0 |

(a) Taking the most negative number in the profit row to indicate the pivot column at each stage, perform **two** complete iterations of the simplex algorithm to obtain tableau T. Make your method clear by stating the row operations you use.

**(9)**

(b) Write down the profit equation given by T.

**(1)**

(c) Use your answer to (b) to determine whether T is optimal, justifying your answer.

**(2)**

**(Total 12 marks)**

**(Q09 6690/01/R, June 2014)**

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**Q7.**
The tableau below is the initial tableau for a linear programming problem in $x$, $y$ and $z$. The objective is to maximise the profit, $P$.

| Basic Variable | $x$ | $y$ | $z$ | $r$ | $s$ | $t$ | Value |
|---|---|---|---|---|---|---|---|
| $r$ | 0 | 1 | 2 | 1 | 0 | 0 | 24 |
| $s$ | 2 | 1 | 4 | 0 | 1 | 0 | 28 |
| $t$ | −1 | $\frac{1}{2}$ | 3 | 0 | 0 | 1 | 22 |
| $P$ | −1 | −2 | −6 | 0 | 0 | 0 | 0 |

(a) Write down the profit equation represented in the initial tableau.

**(1)**

(b) Taking the most negative number in the profit row to indicate the pivot column at each stage, solve this linear programming problem. Make your method clear by stating the row operations you use.

**(9)**

(c) State the final value of the objective function and of each variable.

**(3)**
**(Total 13 marks)**
**(Q08 6690/01, June 2010)**

**Q8.**
While solving a maximising linear programming problem, the following tableau was obtained.

| Basic Variable | x | y | z | r | s | t | value |
|---|---|---|---|---|---|---|---|
| z | $\frac{1}{4}$ | $-\frac{1}{4}$ | 1 | $\frac{1}{4}$ | 0 | 0 | 2 |
| s | $\frac{5}{4}$ | $\frac{7}{4}$ | 0 | $-\frac{3}{4}$ | 1 | 0 | 4 |
| t | 3 | $\frac{5}{2}$ | 0 | $-\frac{1}{2}$ | 0 | 1 | 2 |
| P | −2 | −4 | 0 | $\frac{5}{4}$ | 0 | 0 | 10 |

(a) Write down the values of $x$, $y$ and $z$ as indicated by this tableau.

**(2)**

(b) Write down the profit equation from the tableau.

**(2)**
**(Total 4 marks)**
**(Q08 6690/01, June 2009)**

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**Q9.**
The tableau below is the initial tableau for a maximising linear programming problem in $x$, $y$ and $z$.

| Basic variable | $x$ | $y$ | $z$ | $r$ | $s$ | $t$ | Value |
|---|---|---|---|---|---|---|---|
| $r$ | 4 | $\frac{7}{3}$ | $\frac{5}{2}$ | 1 | 0 | 0 | 64 |
| $s$ | 1 | 3 | 0 | 0 | 1 | 0 | 16 |
| $t$ | 4 | 2 | 2 | 0 | 0 | 1 | 60 |
| $P$ | –5 | $-\frac{7}{2}$ | –4 | 0 | 0 | 0 | 0 |

(a) Taking the most negative number in the profit row to indicate the pivot column at each stage, perform two complete iterations of the simplex algorithm. State the row operations you use.

**(9)**

(b) Explain how you know that your solution is not optimal.

**(1)**

**(Total 10 marks)**

**(Q04 6689/01, June 2008)**

**Q10.**
A three-variable linear programming problem in $x$, $y$ and $z$ is to be solved. The objective is to maximise the profit, $P$. The following tableau is obtained.

| Basic variable | $x$ | $y$ | $z$ | $r$ | $s$ | $t$ | Value |
|---|---|---|---|---|---|---|---|
| $r$ | $-\frac{1}{2}$ | 0 | 2 | 1 | $-\frac{1}{2}$ | 0 | 10 |
| $y$ | $\frac{1}{2}$ | 1 | $\frac{3}{4}$ | 0 | $\frac{1}{4}$ | 0 | 5 |
| $t$ | $\frac{1}{2}$ | 0 | 1 | 0 | $-\frac{1}{4}$ | 1 | 4 |
| $P$ | –7 | 0 | 1 | 0 | 4 | 0 | 320 |

(a) Write down the profit equation represented in the tableau.

**(2)**

(b) Taking the most negative number in the profit row to indicate the pivot column at each stage, solve this linear programming problem. Make your method clear by stating the row operations you use.

**(5)**

(c) State the value of the objective function and of each variable.

**(3)**

**(Total 10 marks)**
**(Q08 6690/01, June 2011)**

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**Q11.**

The tableau below is the initial tableau for a maximising linear programming problem in $x$, $y$ and $z$ which is to be solved.

| Basic variable | $x$ | $y$ | $z$ | $r$ | $s$ | $t$ | Value |
|---|---|---|---|---|---|---|---|
| $r$ | 5 | $\frac{1}{2}$ | 0 | 1 | 0 | 0 | 5 |
| $s$ | 1 | –2 | 4 | 0 | 1 | 0 | 3 |
| $t$ | 8 | 4 | 6 | 0 | 0 | 1 | 6 |
| $P$ | –5 | –7 | –4 | 0 | 0 | 0 | 0 |

(a) Starting by increasing $y$, perform one complete iteration of the simplex algorithm, to obtain tableau T. State the row operations you use.

**(5)**

(b) Write down the profit equation given by tableau T.

**(2)**

(c) Use the profit equation from part (b) to explain why tableau T is optimal.

**(1)**

**(Total 8 marks)**
**(Q08 6690/01, June 2012)**

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