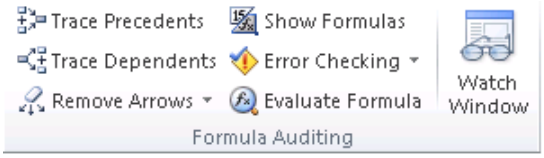
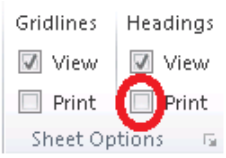
ENGSCI / STATS 255 SC | Assignment 1 | Due: 1:00pm, 08/08/2019

NOTE: Question 3 is a Canvas Quiz due at 12:30pm on Thu 8 Aug.

Instructions for handing in. Please...

1. Attempt **ALL** questions.
2. Assignments may be typed in a word processor of your choice, or handwritten **neatly**.
3. Set answers out in order of the questions. Do **NOT** jump between questions.
4. There is no need to copy the questions out in your submission.
5. Problems entered into Excel **must** include your **student ID** in the **Excel spreadsheet**. Hand in only the sections of computer output that are asked for.
6. You can generate your Excel output either by printing the required reports directly to paper (print in **landscape** mode where appropriate), or by using the Snipping Tool (Windows) or Command - Shift - 4 (Mac). You can display formulae in Excel by using Control - ' or Command - ' or by using Formulas → Formula Auditing → Show Formulas (see image below, left). Excel output showing formulae should include row and column headings; use Page Layout → Sheet Options → Headings → Print (see image below, right) to enable this in printouts.





If you do not enter your student ID in the Excel spreadsheet you will get ZERO marks for the computer output and any questions requiring interpretation of that computer output.

Submission: Assignments must be submitted using Canvas as a **single PDF** file, before the due date and time. Handwritten assignments will need to be scanned. **Prepare your assignments well in advance of the deadline in case of technical issues, as no extensions will be provided in this case.**

Notes:

- Summarising, analysing and communicating information is an important part of Operations Research. For this reason you will be expected to write answers which clearly communicate your thoughts. The mark you receive will be based on **your written English** as well as your technical work.
- **We encourage working together.** Discussing assignments and methods of solution with other students or getting help in understanding from staff and students is acceptable and encouraged. You must **write up your final assignment individually, in your own words.**
- By submitting this assignment, you confirm that you understand the University's policies on cheating, plagiarism and group work; that your submission is entirely your own work and you have not allowed access to any part of the assignment to any other person. **See the appropriate sections in the Course Outline for more details.**
- This assignment consists of **THREE** questions, and is marked out of **50 marks**.
  This assignment makes up **6%** of the final assessment for this course.

Question 1: Creating a Muesli Bar (17 marks)

Ric is a boutique producer of peanut butter that would like to expand into other product categories. At this time, they are developing a new peanut butter and chocolate muesli bar for the American market. The bar must have at least 5g of protein but no more than 5g of carbohydrates and no more than 3g of saturated fats. The table below show the ingredients available, their cost, and their nutritional contributions.

Note that as these bars are to be made in the United States, the weight unit used is dry ounces (oz), and the nutritional requirements are given in terms of grams per dry ounce.

Ingredient	Peanut Butter	Chocolate	Muesli
Cost ($ / oz)	0.10	0.18	0.05
Protein (g / oz)	4.00	0.80	2.50
Carbohydrates (g / oz)	2.50	1.00	18.00
Saturated fats (g / oz)	2.00	0.50	0.30

Because the muesli bar is to be labelled as chocolate flavoured, at least 2 oz of chocolate must be used in the chocolate bar.

Ric would like to find the amount of each ingredient to use in the muesli bar that satisfies all the nutritional requirements above at least cost.

(a) Identify the decision variables for this problem and their units.

(b) Formulate Ric's muesli bar formulation problem as a linear program.

(c) Enter the problem into Excel and solve it to optimality. Your spreadsheet layout should follow that for a standard linear program as given on pages 3.17 to 3.27 in the coursebook. You are advised to use the Excel formula `SUMPRODUCT()` and must have all your decision variables on the left-hand side. Hand in two printouts or screenshots of the resulting Excel spreadsheet, one showing cell values with the optimal solution and the other showing cell formulae. Also hand in a printout or screenshot of Excel's 'Sensitivity Report'. **Follow instructions regarding output from the cover page. Include your ID number on all three printouts.**

(d) Give a brief (1-2 sentences) non-technical interpretation of your results for Ric.

(e) Assume that only the three ingredients mentioned above are used in the muesli bar. What is the total mass of the least cost muesli bar?

(f) Suppose that the cost of chocolate has decreased by $0.10 per dry ounce. How will this affect the optimal solution and optimal cost?

To more fully showcase the taste of Ric's peanut butter, at least 25% of the total mass of the muesli bar must come from peanut butter.

(g) Explain how you would enforce this additional requirement in your linear programming formulation from part (b). Ensure that all your expressions are linear and each variable only appears once in the final expression.

(h) Without re-solving the problem in Excel, do you expect the cost of producing the muesli bar to increase or decrease as a result of this policy? Explain your answer.

You do not need to solve this problem extension in Excel.

Question 2: Purchasing Chocolate Share-Packs (17 marks)

A Professional Teaching Fellow in Engineering Science regularly distributes chocolates to students in his classes as a method of increasing class engagement. The Teaching Fellow purchases all of their chocolates in the form of share packs from Woolworths supermarkets, which stock chocolates from four different manufacturers.

The following table gives a summary of the different chocolate sharepacks that are available.

Manufacturer	Chocolate	Units per pack	Cost per pack	Energy (kJ)
Cadbury	Milky Dairy	15	\$ 3.50	270
	Crunchy	12	\$ 3.50	292
	Prime Cherry	12	\$ 2.75	300
Whittakers	Hokey Pokey	12	\$ 5.40	327
	Lime + Gore	12	\$ 5.20	336
Mars	Snackers	12	\$ 3.90	370
	Twist	12	\$ 3.70	308
	Venus	12	\$ 3.50	340
Nestlé	Blocky Milk	11	\$ 4.80	340
	Wit-Wat	11	\$ 4.50	370

The Teaching Fellow would like to maximise the number of units of chocolates that are purchased, but must not exceed a budget of \$150. The Teaching Fellow would like to purchase at least 10 share packs of Whittaker's chocolates as it is seen as premium, and at least 5 share packs from each of the other manufacturers.

Student preferences mean that the number of sharepacks of Nestlé chocolates purchased must be no more than 50% of Cadbury and Mars sharepacks combined.

Note: You may ignore any integer requirements in this problem.

(a) Identify the decision variables required to model this problem, and their units.

(b) Formulate the Teaching Fellow's chocolate purchasing problem as a linear program.

(c) Enter the problem into Excel and solve it to optimality. Your spreadsheet layout should follow that for a standard linear program as given on pages 3.17 to 3.27 in the coursebook. You should use the Excel formula `SUMPRODUCT()` and have all your decision variables on the left-hand side. Hand in two printouts or screenshots of the resulting Excel spreadsheet, one showing cell values with the optimal solution and the other showing cell formulae. Also hand in a printout or screenshot of Excel's 'Sensitivity Report'. **Follow instructions regarding output from the cover page. Include your ID number on all three printouts.**

(d) Give a brief (1-2 sentences) non-technical interpretation of your results to the Teaching Fellow.

(e) Government dietary requirements mean that the Teaching Fellow must not distribute more than 300kJ per unit of chocolate given out, *on average*. How should your linear program in (b) be changed to model this situation? **Show only your changes and make sure your new constraint(s) are LINEAR. You do not need to solve this problem in Excel.**

(f) Suppose that Milky Dairy is also available in a 20-unit sharepack at a cost of \$5 per pack. How should your linear program in (b) be changed to model this situation? **Show only your changes and make sure any new constraint(s) are LINEAR. You do not need to solve this problem in Excel.**

Question 3: Farm Production – Canvas Quiz (16 marks)

This question has been set up as a Canvas Quiz; this is due Thursday 8 August at 12:30pm. (30 minutes before Q1 and Q2 are due on Canvas.)

You have up to three attempts at the Canvas Quiz. Each attempt is time limited to three hours. All attempts will be automatically submitted at the due time, so please leave sufficient time to give the questions a good attempt.

Use the following problem description, formulation and sensitivity report to answer the quiz questions.

NOTE: Each question is independent of the others.

A small dairy farm would like to maximise the profit generated from the production of cream, milk, butter, (milk) powder and yoghurt at a small farm with limited supplies of milk fats, milk protein, and hours of staff labour. The farm also has contractual restrictions on the amount of milk that can be produced. The units used in this model are kilograms, hours and dollars per week. All profits are in $/kg.

	A	B	C	D	E	F	G	H	I
1		Cream	Milk	Butter	Powder	Yoghurt			
2		15.09804	20	0	0	16.47059			
3									
4	max	1.5	1.4	1.7	1.2	1.3	72.1		
5									
6	AvailableFats	1	0.9	1.2	1	0.7	44.6	<=	50
7	AvailableProtein	0.6	0.8	1.1	1.7	0.3	30	<=	30
8	Labour	0.3	0.2	0.6	0.9	1	25	<=	25
9	MinimumMilk		1				20	>=	20
10	MaximumMilk		1				20	<=	45

Adjustable Cells

Cell	Name	Final Value	Reduced Cost	Objective Coefficient	Allowable Increase	Allowable Decrease
B2	Cream	15.09803922	0	1.5	1.1	0.324324324
C2	Milk	20	0	1.4	0.470588235	1E+30
D2	Butter	0	-1.082352941	1.7	1.082352941	1E+30
E2	Powder	0	-3.082352941	1.2	3.082352941	1E+30
F2	Yoghurt	16.47058824	0	1.3	2	0.55

Constraints

Cell	Name	Final Value	Shadow Price	Constraint R.H. Side	Allowable Increase	Allowable Decrease
G6	AvailableFats	44.62745098	0	50	1E+30	5.37254902
G7	AvailableProtein	30	2.176470588	30	3.46835443	7.7
G8	Labour	25	0.647058824	25	22.83333333	14
G9	MinimumMilk	20	-0.470588235	20	10.40540541	13.90862944
G10	MaximumMilk	20	0	45	1E+30	25