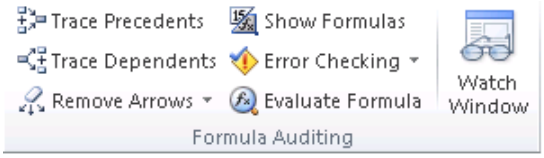
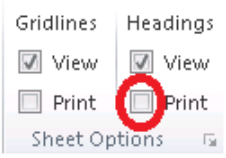
ENGSCI / STATS 255 SC | Assignment 2 | Due: 1:00pm, 22/08/2019

NOTE: Question 4 is a Canvas Quiz due at 12:30pm on Thu 22 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: Producing Shower Curtains (14 marks)

Aperture Laboratories is a world-leading producer of shower curtains for use in the military. A very large order has just been accepted, and *Aperture* needs to create a new staff roster to ensure production targets are met. They can employ up to 8 experienced staff, who each work 6 hour shifts, and up to 22 inexperienced staff members who each work 2 hour shifts. Assume that each staff member can only do one shift per day. Experienced staff are paid at \$19 **per hour**, and inexperienced staff are paid at \$13 **per hour**. Experienced staff can start work at 9am or 11am, whilst inexperienced staff can start at 9am, 11am, 1pm or 3pm.

To allow for some level of quality control, *Aperture* wants to ensure that there is at least one experienced staff member available at all times between 9am and 5pm. The shipping company retrieves orders daily at 12pm. To help load the trucks, *Aperture* would like to ensure at least four of the staff required at this time are inexperienced staff members.

Period Number	Time Period	Minimum Number of Staff
1	9am – 11am	3
2	11am – 1pm	8
3	1pm – 3pm	5
4	3pm – 5pm	9

(a) Identify the decision variables for the problem.

(b) Formulate the problem of minimising the total cost of the day's shifts as an integer program. Clearly state your objective function and constraints.

(c) Enter the problem of part (b) into Excel and solve it to optimality (i.e. using a zero tolerance). Your spreadsheet layout should follow that for a standard linear program as given on pages 3.17 and 3.27 of the workbook. Hand in two printouts or screenshots of the resulting Excel spreadsheet, one showing values and the other showing formulae. **Follow instructions regarding output from the cover page. Remember to include your ID number on both printouts.**

(d) Give a brief (2 – 3 sentences) English interpretation explaining Excel's answer to *Aperture Laboratories*. Include the shift details and total cost.

(e) A staff shortage means that only 3 inexperienced staff members are available to start at 1pm. If further inexperienced staff are required, they must be hired from an external contracting company which charges \$70 to provide any number of additional staff members. Show how this situation can be modelled in your integer program from part (b).

Question 2: Shipping Military Androids (11 marks)

Aperture also produces a hugely successful range of armed androids designed to be sentries for military use. The CEO of *Aperture*, Cave Johnson, has asked you to develop a plan to produce and ship these androids at least cost.

Aperture has warehouses in Cleveland and Detroit, which can supply 200 and 250 androids per month, respectively. These androids need to be delivered to three cities: New York, Miami and Toronto, which demand 130, 80 and 180 androids per month, respectively. Androids produced at Detroit cost **$2 each**, and androids produced at Cleveland cost **$3 more** than androids produced at Detroit.

The cost of shipping each robot is given in the table below.

From / To	Cleveland	Detroit
New York	10	20
Miami	7	9
Toronto	11	23

(a) Formulate the problem of minimising the **transportation and production** costs as an **unbalanced** transportation problem. Use the standard Tabular Transportation format given in lectures with the $\leq$ **supply constraints in the rows**, and remember to include all costs, supplies, demands and any bounds that are needed.

(b) Enter the problem of part (a) into Excel and solve it. Hand in three screenshots or printouts: two of the resulting Excel spreadsheet, one showing the optimal values and the other showing the formulae; and one of the resulting sensitivity report. **Remember to include your ID number on all printouts.**

(c) Give a **brief** English interpretation of Excel's answer to *Aperture Laboratories*.

(d) The Florida state government has decided to ban the importation of armed androids into Miami. Using **only** the sensitivity report, advise *Aperture* on how the cost of the optimal plan will change. Clearly explain your answer. **Re-solving the problem will score no marks.**

(e) Due to the lack of maintenance on key infrastructure, the route between Detroit and Toronto can no longer be used. Give two methods to enforce this constraint.

Question 3: Innovating More Science (15 marks + 3 bonus marks)

Aperture Laboratories is engaged in a perpetual competitive war against the *Black Mesa Research Facility* in terms of innovating products at the forefront of human discovery. As a result, *Aperture* is keen to **maximise the profit** from innovation in the next three months. There are sufficient staff for 6 prototypes to be generated per month, and each prototype costs \$10,000 to generate. Once a prototype is generated, it will be tested; there is capacity for 4 prototypes to be tested in each month. A tested prototype is worth \$18,000 to the company. Prototypes may be held for testing at a later month, at a cost of \$1,000 per prototype per month.

It is also possible to hire agents to spy on *Black Mesa* in Month 2; this can generate a maximum of 2 extra prototypes – each prototype generated in this manner will cost *Aperture* \$20,000. Further, it is possible to hire out testing spaces in external facilities; one extra prototype can be tested in each month, and it costs *Aperture* \$15,000 per month to hire this facility, if it is used.

The prototypes have a 100% track record of passing the tests, and we assume this will continue.

In this question, you should work in units of \$1,000.

(a) **By hand**, draw a diagram showing a transshipment formulation for this problem. You should use a maximisation objective. Your diagram must follow the standard transshipment diagram representation given in lectures; your answer should *not* include any equations.

(b) Using the appropriate spreadsheet provided on Canvas, enter this problem into Excel and solve it to optimality. Hand in a screenshot or printout of the resulting Excel spreadsheet, showing the data entry table, the optimal values and the network diagram. **Remember to include your ID number on the spreadsheet.**

   i. **3 BONUS MARKS:** Formulate this problem **AGAIN** using the `SUMIF()` formulation method described on p. 11.16 of your coursebook. Note that it is not possible to use dummy demand and supply nodes in this method – so you need to think carefully about how the prototype and testing 'flows' are modelled. You must submit both the solution and formula view. A network diagram is not required.
   A correct formulation and solution scores all 3 bonus marks. Partial marks are given at the discretion of the marker.
   There will only be limited help available for this particular task, as it is not examinable.

(c) Give a brief English interpretation of Excel's answer to *Aperture Laboratories*.

(d) A computer fault means that the **combined** joint capacity for testing and storage in month 2 is two prototypes. Show how your network diagram would be modified to take this into account. **You do not need to solve this problem in Excel.**

(e) Now suppose the testing capacity in month 1 is 6 prototypes (and they have fixed the computer issue in part (d)). Will the expected profit increase or decrease? Justify your answer. **You do not need to solve this problem in Excel, nor consider any sensitivity analysis output.**

Question 4: Odds and Ends – Canvas Quiz (10 marks)

Revision is best done early and often, so we will start now... This Canvas Quiz covers a number of concepts that cannot easily make it into an assignment.

This quiz covers concepts from the whole LP topic, and you will receive a random set of ten questions each time. You have three attempts at the quiz, with each attempt timed at 90 minutes. We will take the best mark from your three attempts.

The quiz opens on Thursday 15 August at 5pm, and is **due at 12:30pm on Thursday 22 August**, 30 minutes before the PDF submission of Questions 1 – 3. You will not be able to attempt the quiz after the due time and all ongoing attempts will be automatically submitted.

You will be able to see your score immediately after submitting the quiz, but the answers will not be shown until after the due time.

Please do not discuss quiz questions on Piazza or any other forum.