Carleton University
Systems and Computer Engineering
SYSC-3200: Industrial Engineering
Fall Term 2013
Assignment 3
Due by 6:00 p.m. on Tue. November 12 at the beginning of the class. Assignments submitted after this deadline, but before marked assignments are returned or solutions are posted, are subject to a 50% penalty. No credit thereafter.

Notes on Problem Solutions (for all questions on assignments, midterms, exam):
Show the details of your formulation, including:

- the definitions of the decision variables, including their units and their bounds,
- the objective function and the constraints as mathematical expressions in the decision variables. Provide labels for the constraints and objective function indicating the physical meaning of each (e.g. "limit on capacity of plant 3"), and their units.

Summarize the results in terms of the original problem as though you were reporting to a manager. If the results are unusual in any way, state why this might be so.

Be succinct. Each solution should require no more than a couple of pages.

1. [10 marks] The following diagram represents the storm sewer system that carries rainwater from a neighbourhood at A to the Ottawa River at K. Each storm sewer line is labeled with its maximum capacity in cubic metres of water per second.
   a) What is the maximum flowrate of water from A to the Ottawa River?
   b) Show a flow pattern that achieves this maximum flow.
   c) Suppose that the maximum flowrate is insufficient for anticipated major storms as global warming affects the amount of rainfall received in Ottawa. Which pipes should the city consider expanding in order to increase the maximum flowrate of the storm sewer system?
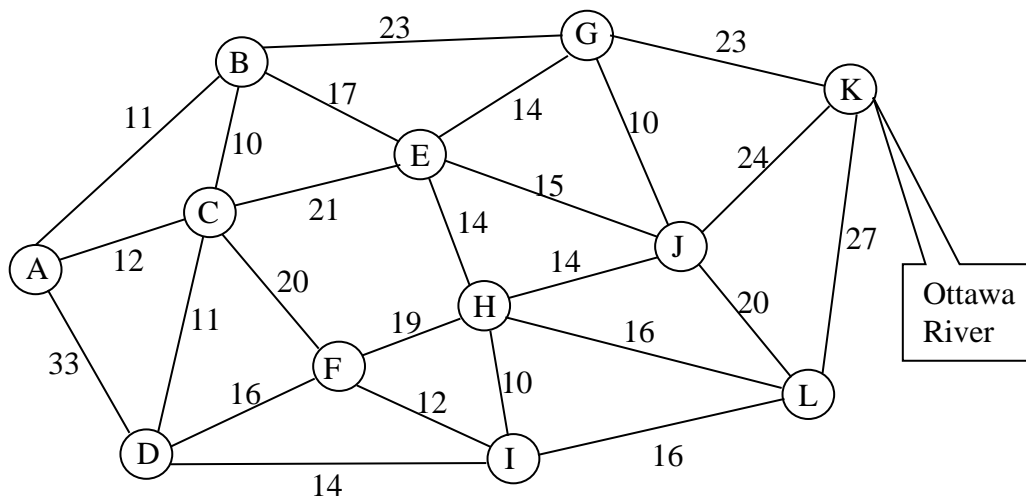
2. [10 marks] The PERT chart below shows the activities involved in programming a new web browser. Each arc is labeled with the number of days it will take to complete.
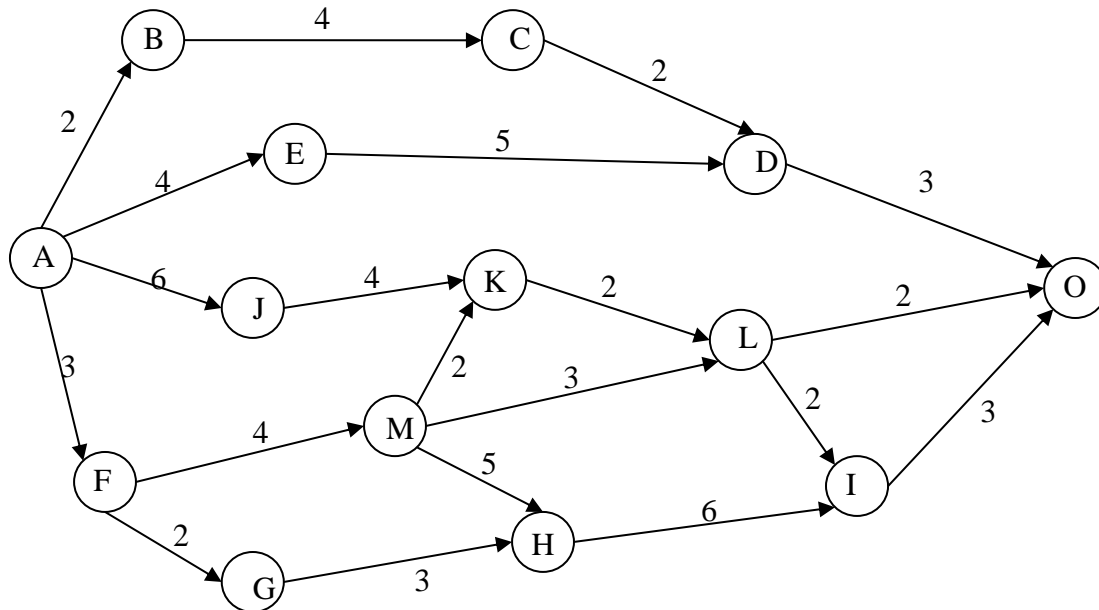
a) The project must be completed within 3 weeks. Is this possible?

b) Which activities must be done on time to make sure that the whole project completes on time?

c) If each activity is uninterruptible once it begins and each requires a team of programmers (each team contains a fixed number of personnel with different skills), can this project be completed on time using just 3 teams of programmers?

3. [10 marks] A swim coach is trying to determine the best way to assign her swimmers to the legs of a medley relay race. She has four swimmers, and each takes a certain amount of time to swim a given leg, as shown in the table below (in minutes). The coach figures that, if necessary, a swimmer can swim more than one leg, provided she skips at least one leg between legs that she swims. For example, if the swimmer is assigned to leg 1, then she could also be assigned to swim leg 3 (but not leg 2). How should the swimmers be assigned to the legs to minimize the total time taken? What is the minimum expected total time taken?

	1. Breaststroke	2. Backstroke	3. Crawl	4. Butterfly
Anne	4.3	3.7	4.6	3.2
Bridget	4.0	3.5	4.5	3.0
Charlotte	4.4	3.6	4.7	3.1
Darlene	4.1	3.7	4.8	3.2

4. [10 marks] Several student groups (A through F) have to provide at least one representative to attend an awards ceremony in Vancouver. The 8 possible representatives (R1 through R8) are members of the various groups, most belonging to multiple groups, as indicted by an x in the table below. The travel costs for each representative differ as shown in the table, depending on where they will be travelling from. The Dean is funding the student travel and so wishes to minimize the total travel costs while making sure that at least one representative from each student group is at the awards ceremony. Which representatives should the Dean select to travel to the ceremony? What is the minimum total cost of travel?

a) Formulate this problem for solution by Balas additive algorithm. Solve only as far as the first incumbent solution.

b) Solve this problem using an integer programming solver (e.g. LINDO). Note that the LINDO keyword INT indicates a binary variable.

representative	Groups						Cost
	A	B	C	D	E	F	
R1	x			x			$500
R2		x	x				$400
R3		x				x	$600
R4	x					x	$475
R5				x		x	$550
R6			x				$300
R7		x			x		$575
R8	x				x		$525