

University of Toronto
Faculty of Applied Science and Engineering
Final Examination, December 06, 2013

Duration: 2.5 hours

APS111H1 F and APS113Y1 Y - Engineering Strategies & Practice 1

Calculator Type: 4 (No electronic or mechanical devices permitted)

Exam Type: A (Closed book, no aids permitted)

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Instructions:

This is a closed book exam; no calculators or aids are permitted, except for a translation-only dictionary, i.e., direct word-to-word translations but no definitions. There are two parts of the exam: multiple-choice questions, and a writing component. Read each question carefully.

For the multiple-choice portion, provide the most correct answer to each question on the answer sheet. Only one answer is to be given for each question. Be sure to fill out the answer sheet clearly with no overlaps, using a pencil. Erase any errors completely. There are a total of 37 multiple-choice questions, each of which is worth about 1.6 marks, for a total of 60 marks worth 60% of the exam.

The second part of the exam is a writing component worth 40% of the exam. Answer this part in the exam booklet carefully following the instructions.

Write your name and student number on both the multiple-choice answer sheet (scan sheet) and the exam booklet where you do the writing component. When you are done with the exam, insert the answer sheet in the exam booklet and submit them together.

$$MC \Rightarrow \frac{33}{37}$$

89%

Hold my dick APS111

52.8
60

52.2
84
40
Needed

Part 1: Multiple-choice questions (60%)

1. Figure 1 shows time along the horizontal axis and net cash flow along the vertical axis.

A, B, and C represent:

- a. A = Costs; B = Pay Back Period; C= Benefits
- b. A = Net Loss; B = Break Even Point; C = Net Revenue
- c. A = Outlay; B = Net Present Value; C = Income
- d. A = Taxes; B = CPI; C = Profit

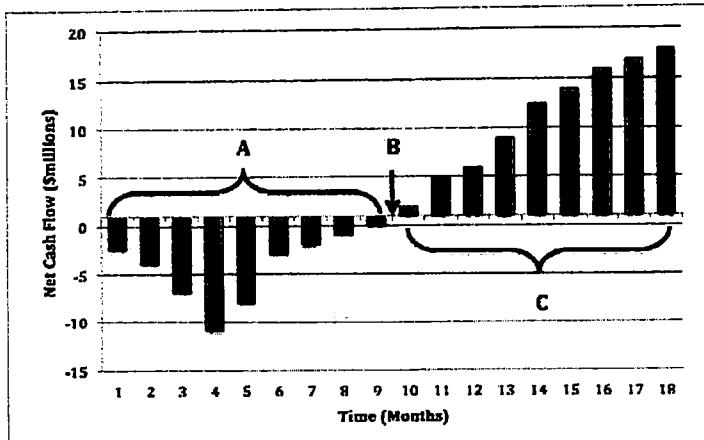


Figure 1: Cash Flow Diagram

2. According to an article published in the November 25 edition of the Globe and Mail newspaper, an international team of engineers is studying owls, hoping the mysteries of their stealthy flight might lead to improvements in the design of everything from aircraft to submarines. The design approach that the engineers are using is called:

- a. Life cycle assessment.
- b. Bioaccumulation.
- c. Pollution prevention.
- d. Biomimicry.

3. Industrial ecology uses a systems approach to optimize material and energy flows by using outputs from one process as inputs to another process. Industrial ecology has many benefits and has been successfully applied in Kalundborg, Denmark. However, a disadvantage of industrial ecology is that it:

- a. Can only be applied in Europe.
- b. Requires tax incentives to operate efficiently.
- c. Does not encourage reduction of emissions and wastes.
- d. Only works with linear systems.

- A 4. When you are working on an engineering design, knowing your stakeholders and anticipating their concerns is a strategy that can increase acceptance of your design. Stakeholder analysis is a useful approach for:
- a. Identifying the stakeholders, prioritizing their interest and influence, and understanding their issues and concerns.
 - b. Connecting stakeholder interests to the Project Requirements.
 - c. Avoiding laws suits.
 - d. Government projects only, because private companies do not have to consider stakeholders.
5. Methods for choosing among different alternatives to solve an engineering design problem can be categorized as quantitative and qualitative. An example of a quantitative method is:
- a. Environmental assessment.
 - b. Stakeholder analysis.
 - c. The engineering design process.
 - d. Break even analysis.
6. The Critical Path Method was developed in 1960 by DuPont. It captures tasks, task durations, and how tasks relate to each other. It is a useful tool for managing engineering design projects because it identifies the "critical path", which is:
- a. The minimum amount of time you need to finish the project.
 - b. Shown by a Venn diagram.
 - c. The maximum time from the beginning to the end of the project.
 - d. The route that your client has prioritized.
7. In Ontario, the Professional Engineers Act and Regulation prescribe the Code of Ethics. Section 77 of Regulation 941 states that "it is the duty of a practitioner to the public, to the practitioner's employer, to the practitioner's clients, to other licensed engineers of the practitioner's profession, and to the practitioner to act at all times with (i) fairness and loyalty to the practitioner's associates, employers, clients, subordinates and employees; (ii) fidelity to public needs; (iii) devotion to high ideals of personal honour and professional integrity; (iv) knowledge of developments in the area of professional engineering relevant to any services that are undertaken; and (v) competence in the performance of any professional engineering services that are undertaken." This means that, once you become a licensed engineer, you:
- a. Can decide when to apply the Code of Ethics depending on the type of project you are working on.
 - b. Do not need to seal engineering drawings.
 - c. Are not legally liable for your actions as a licensed engineer because engineering is a self-regulated profession.
 - d. Have a clearly defined duty to society, which is to regard the duty to public welfare as paramount.

Questions 8 to 9 relate to the Team Case Study below.

Aliyah, Bart, Chandak, and Derin are the four members of an APS111 team that has undergone significant storming. Bart, the original team leader, was highly aggressive in setting team goals, and quickly took over duties if anyone on the team showed signs of not meeting deadlines or quality expectations. This resulted in little buy in from the other team members and when Bart left, the team was stalled. After an intense team meeting Derin agreed to take over as team leader. She has been an effective leader acting quickly to make up for lost time by assigning all team members equal amounts of work on the project.

8. What strategy could Bart have used to better lead his team?
- a. Write team rules that punished underperformers by assigning them earlier internal deadlines for the next assignment.
 - b. Have all team member submit their work to him for approval before allowing it to be put into the team document.
 - c. Remove any individuals work with more than three errors in it, rewrite it, and remove that person from the attribution table.
 - d. Replace internal deadlines with two-hour meetings where the team jointly combines the individual work into a team document.
- 9. What is Derin's Bolton and Bolton leadership style?
- a. Analytical
 - b. Driver
 - c. Expressive
 - d. Amiable

Questions 10 to 33 pertain to Case Study #1: Enbridge Line 9B located in the appendix of this exam.

10. The mandate of the NEB is to promote safety and security, environmental protection and economic efficiency in the Canadian public interest within the mandate set by the Parliament of Canada in the regulation of pipelines, energy development and trade. The *National Energy Board Act* requires oil pipeline companies, such as Enbridge Pipelines Inc., to obtain approval from the NEB before building new pipelines or making changes to existing pipelines. The *National Energy Board Act* is an example of legislation that:
- a. Balances environment, economy, and society.
 - b. Favours oil and gas companies.
 - c. Applies the precautionary principle.
 - d. Was developed by the Ontario government.

1. Benzene is an organic chemical compound found in crude oil. Studies in the scientific literature, including studies by Health Canada and the United States Environmental Protection Agency, have demonstrated that benzene breaks down in air and dissolves in water. The studies also demonstrated higher cancer rates among workers exposed to benzene. Based on the studies, benzene can be described as a compound that:
- Bioaccumulates and is carcinogenic.
 - Bioaccumulates and is not carcinogenic.
 - Does not bioaccumulate and is not carcinogenic.
 - Does not bioaccumulate and is carcinogenic.
2. Fearing a repeat of the 2010 disaster on Line 6 in 2010 that saw over 3 million litres of oil spill into the Kalamazoo River, the municipalities of the Greater Toronto Area (GTA) are concerned about the potential impact of a spill from Line 9B on the quality of drinking water. This is because conventional municipal water treatment plants are not designed to treat water that is contaminated with crude oil. The municipalities participated at the Line 9B hearing and asked the NEB to require Enbridge to take actions that would reduce the chances of a release of crude oil from Line 9B. The actions the municipalities want Enbridge to take are intended to:
- Mitigate risk.
 - Control pollution.
 - Reduce crude oil production.
 - Increase the price of gasoline.
3. The municipalities of the GTA are pressing for assurances any spills that do occur would be detected quickly in order to reduce the negative environmental impacts. As the engineer responsible for the design of the interface of the rupture detection system you have anticipated these concerns. You have conducted interviews of Enbridge personnel who were on the Line 6 rupture detection team in 2010 (see question 12) to identify problems in the relationship between the sensor system and the operators. You are using the Human Tech design principle of:
- Shape Coding
 - Critical-Incident Technique
 - Feedback Design Principal
 - The Human Tech Ladder
4. In 2009, Enbridge announced a plan of current and future actions to (1) support flexible community-based training specific to the pipeline sector, (2) invest in renewable and alternative energy technologies, and (3) deliver superior long-term value to Enbridge shareholders as measured by total shareholder return. The plan demonstrates Enbridge's commitment to:
- Sustainability.
 - Prosperity.
 - Profitability.
 - Biodiversity.

- ✓ 15. Enbridge owns and operates Line 9B, and uses it to transport crude oil for its clients, which are companies such as Suncor Energy Inc. and Imperial Oil Ltd. Other companies that own and operate pipelines in Canada are TransCanada Pipelines and Keystone Pipelines, so there is competition for clients. Which of the following statements best describes what Enbridge did before deciding to file its application to the NEB:
- a. Called the NEB and explained why the flow in Line 9B should be reversed.
 - b. Assigned its engineering department to prepare a business case to determine how to enhance Enbridge's share of the crude oil pipeline market.
 - c. Tested the corrosivity of crude oil on different types of internal pipeline coatings.
 - d. Examined the possibility of re-locating Line 9B to the United States.
- ✗ 16. In 2010, the energy sector in Canada, including service stations and wholesale trade in petroleum products, provided direct employment for 356,000 people. This represented 2.43 percent of all employment in Canada. If the Line 9B application is approved by the NEB, Enbridge predicts 6,000 more jobs will be created over a 10 year period, increasing energy sector employment to 2.47 percent. This increase in Canada's overall employment is the result of a:
- a. Microeconomic Analysis.
 - b. Macroeconomic Analysis.
 - c. Change in Consumer Price Index.
 - d. Change in Gross Domestic Product.
- ✓ 17. Right now, Line 9B is used to transport foreign crude oil, including from Nigeria, which is among the top 10 oil-producing countries in the world. All of Nigeria's oil and gas resources come from the Niger delta region, which is also home to many indigenous peoples including the Ogoni. One significant impact of the oil industry in Nigeria has been destruction of the mangrove forest, which serves as a habitat for fish and mollusks and is a source of raw materials for the Ogoni people. Due to pollution from the Nigerian oil industry, the mangrove forest can no longer support the subsistence life upon which the local Ogoni community depends. In the context of Line 9B, the loss of the mangrove forest is:
- a. The cost of doing business.
 - b. Part of the life cycle cost of the pipeline.
 - c. An external cost.
 - d. An internal cost.
- ✗ 18. The loss of the mangrove forest in the Niger delta, and the subsequent impacts on the Ogoni community that depend on it, is an example of:
- a. How design can impact social conditions.
 - b. Why it is better to ship foreign oil to Canada than use crude oil from the Alberta oil sands.
 - c. The importance of changing the service environment.
 - d. Poor decision making by local community leaders.

- ✓ 9. The public hearings that the NEB held in October, 2013, gave many individuals and organizations an opportunity to express their concerns and can be considered a good example of:
- Taxpayer overexpenditure.
 - Government regulation.
 - Third party certification.
 - Stakeholder engagement.

- 20. There are a number of fixed and variable costs that Enbridge incurs to operate Line 9B. The pipeline lies within lands owned by municipalities, the provincial government, First Nations communities, and individuals, and Enbridge pays a monthly fee of \$100,000 to lease the land from the landowners. Enbridge has a regulatory requirement to inspect 200 valves located along Line 9B every year at a cost of \$5,000 per inspection. The cost to pump the crude oil through the pipe is \$0.02 per barrel. What is the annual cost to operate Line 9B if the application is approved and Enbridge uses the full capacity of 300,000 barrels per day, but operates only 10 months of the year?

- $200 \times 500 = 100,000$
 $2 \times 5000 + 2000$
 $= 1000000$
 millions
- \$4,190,000 per year.
 - \$4,390,000 per year.
 - \$4,025,000 per year.
 - \$3,658,333 per year.

10 months \$100,000/month
 $\boxed{\$1000000}$ millions
 $\$0.02/\text{barrel} \times 300,000 \text{ barrels}$
 $\$0.02/\text{barrel} + \$5000 \times 300 = \boxed{\$18000}$
 $\boxed{305 \text{ days}}$
 $305 \text{ days} \times \$1000000 = \$305,000,000$
 $\boxed{\$305,000,000}$

- 21. You have been hired to work on the capacity expansion of an oil refinery for a company in Sarnia. The company has given you the Gantt chart shown in Figure 2. Which of the following statements is **TRUE**?

- ✗ a. You can calculate the critical path because the Gantt chart shows how much time is needed for each task.
- b. The Gantt chart can be used as a project management tool because it shows when tasks occur.
- c. How one task relates to another is not important for this project because there are only a few tasks to complete.
- d. You only have 12 months to complete all the tasks, so there is not enough time to finish the project.

$1 + 2 + 3 + 3 + 4 + 5 + 6 + 14 + 16 + 18 + 10 + 11 + 12$

Task	Description	Months											
		1	2	3	4	5	6	7	8	9	10	11	12
1	Project Initiation	X											
2	Define Scope and Objectives		X	X									
3	Formulate Alternatives			X	X	X							
4	Evaluate Alternatives				X	X	X	X					
5	Analyze Stakeholder Concerns					X	X	X	X				
6	Identify Preferred Alternative						X	X	X				
7	Presentation to Client									X			

Figure 2: Gantt Chart

- ✓ 22. In the federal Storage Tank Systems for Petroleum Products and Allied Petroleum Products Regulations made under the Canadian Environmental Protection Act, removal of storage tanks or any components of storage tanks that are covered by the Regulations is required to be supervised by a professional engineer. This requirement is an example of:
- Environmental protection.
 - Demand-side legislation.
 - Public safety.
 - Poor public policy.
- ✓ 23. Your company has been hired by Enbridge to upgrade the pumps at the pumping stations along Line 9B. As the design engineer responsible for evaluating the alternatives, you have identified two options: (1) *full head pumps*, which are two-stage pumps with the impellers in series; and (2) *half stage pumps* with the impellers in parallel. Based on the cost and technical information from pump manufacturers shown in Table 1, the following recommendation can be made to Enbridge:
- Full Head Pumps should be installed because the payback period exceeds the service life of the pumps.
 - Full Head Pumps should be installed because the service life is longer.
 - The capital cost for the Half Head Pumps is higher because they are twice as efficient as the Full Head Pumps.
 - Enbridge should install Half Head Pumps because the service life of the pumps is longer than the payback period.

Table 1: Pump Options

Alternative	Capital Cost (\$)	Annual Operating Savings (\$/year)	Service Life (years)
Full Head Pumps	\$200,000	\$15,000	10 years
Half Head Pumps	\$360,000	\$52,000	7 years

$\frac{200,000}{15,000} = 4 \text{ years}$ 360,000
 $\frac{360,000}{52,000} = 6.9 \text{ years}$ 5th year
6.5 years pay
 $15 = 1 \text{ year}$
 $20 = 2 \text{ years}$
 $50 = 4 \text{ years}$
 $180 = 12 \text{ years}$

- ✓ 24. As the engineer in charge of pipeline operations, one of your tasks is to monitor and report on labour and equipment costs every quarter. This information is used in quarterly reports that Enbridge files with the Toronto Stock Exchange and makes available to shareholders. If the NEB approves the Line 9B application, you will need to hire more workers at the western end of the pipeline to supervise delivery of the crude oil to the refineries in Sarnia. Your research shows that labour costs in Ontario are higher than in Quebec, but the taxes Enbridge must withhold on Ontario worker salaries are lower. Which of the following reasons will you use to explain the differences?
- Time value of money.
 - Inflation.
 - Supply and demand.
 - Regional variation.

25. Bitumen needs to be diluted so it can flow in pipelines and a common practice is to use naphtha, which is obtained from natural gas condensate. The naphtha is blended with the bitumen in ratios of up to 55%. Once the dilbit has been pumped to the refinery, the naphtha can be removed and returned to the bitumen production source for blending with the next quantity to be piped. Which of the following statements is TRUE?
- a. Removing and returning naphtha to the production source for blending with another quantity of bitumen is an example of re-use. ←
 - b. Naphtha must be returned to the bitumen production source because it is too costly for the refineries to process.
 - c. The price of crude oil is lower than bitumen because there is no need to add naphtha to crude oil in order to transport it via pipeline.
 - d. Transporting dilbit by pipeline is not sustainable because the viscosity and density are too high for it to flow in the pipeline without adding naphtha.
- ✓ 26. Enbridge has hired your company to conduct a life cycle assessment (LCA) on its Line 9B pipeline. Enbridge expects you to use one of the two standards for conducting life cycle assessments: ISO 14040 or ISO 14044. These standards explain the four-step process you should follow, including analysis of the inputs and outputs, assessment of the impacts, and interpretation of results so you can advise Enbridge how to improve its pipeline. However, the most important first step is for you to:
- a. Develop a proposal to explain how you are going to conduct the LCA.
 - b. Sign the contract with Enbridge.
 - c. Agree with Enbridge on a manageable scope for the LCA.
 - d. Tell Enbridge how much the LCA will cost.
- ✓ 27. Leadership in Energy and Environmental Design (LEED) is an internationally recognized standard for the construction industry to assess the environmental sustainability of building designs. LEED is a rating system that awards points for building attributes with a net environmental benefit. For example, points can be earned for using renewable energy. Enbridge's Line 9B would not qualify for a LEED designation because:
- a. LEED only applies to buildings.
 - b. Crude oil cannot be recycled.
 - c. Pipelines already have net environmental benefits built in.
 - d. It is not allowed under the *National Energy Board Act*.
- ✗ 28. Maggie is an APS111 student doing her seminar presentation on the Enbridge Line 9B application. She takes the position that Enbridge's application for reversal of Line 9B should be refused. The best argument for her position is:
- a. Project benefits are limited when LCA determined externalities are factored in.
 - b. Numerous First Nations and environmental groups oppose the reversal as a threat to the water system integrity.
 - c. There may be more complications in implementation than indicated by Enbridge.
 - d. Greenpeace's assumption that the pipeline will spill is valid.

- 29. In her seminar presentation on the Enbridge Line 9B application Maggie uses the following sources of information:

- [1] Greenpeace. (2013). Stop the Enbridge pipeline [Website]. Available: <http://www.greenpeace.org/canada/en/campaigns/Energy/tarsands/Get-involved/stop-the-pipeline/>
- [2] Enbridge. (2013) Looking at Enbridge's Spill Record in 2009. [Website] Available: <http://www.enbridge.com/AboutEnbridge/CorporateSocialResponsibility/Environment/LookingAtEnbridgesSpillRecord.aspx>

From these sources she uses the following information:

"According to the environmental advocacy group Greenpeace between 1999-2008, Enbridge had an average of one spill every week from its pipelines, however Enbridge regards its safety record as favourable, in comparison to other companies."

This is acceptable because:

- a. Greenpeace is a reputable organization.
- b. Enbridge presents unbiased figures on spills.
- c. The data she provides from both Greenpeace's and Enbridge's website support a valid conclusion.
- d. She identifies the bias of Greenpeace.

- ✓ 30. For the Enbridge Line 9 Case Study, which of the following is a useful statement of Stakeholder, Interest, and Impact on the design's Functions, Objectives and Constraints (FOC).

Stakeholder	Interest	Impact on FOC
<input checked="" type="checkbox"/> a.	Industry groups	Profit Ensure that pipe line changes are approved quickly
<input checked="" type="checkbox"/> b.	Environmental groups	Expose environmental problems Close down and remove pipeline to restore natural environment
<input checked="" type="checkbox"/> c.	First Nations Peoples	Well-being of its communities Leak detection so that leaks can be spotted as early as possible
<input checked="" type="checkbox"/> d.	Enbridge	Safety Public information campaigns to prevent third-party damage

- ✓ 31. Industrial ecology is sometimes referred to as "cradle-to-cradle" environmental management. The goal of industrial ecology is for man-made systems to emulate efficient, sustainable natural systems by optimizing the total materials and residuals cycle taking into consideration resources, energy, and costs. Your company would like to propose industrial ecology to Enbridge. One of the first things you must do is:
- Solicit funds from the federal government so that Enbridge can retrofit its pipelines to accept compressed natural gas.
 - Identify companies, municipalities, and individuals who realize that waste and residuals from one process can be used as inputs to another process.
 - Wait for the NEB to release its decision about the Line 9B application.
 - Talk to the Ogoni community in Nigeria about the loss of the mangrove forest.
- ✓ 32. As the chief chemical engineer for Enbridge, your role is to test the chemical composition of dilbit, which is a combination of bitumen and a diluting agent such as naphtha. The American Society for Testing and Materials (ASTM) has recently released a methodology for evaluating crude oils, including dilbit, under conditions normally occurring in oil and gas production, storage and transportation in pipelines. You ask your colleague about using the new methodology, but your colleague says not to bother because it will be more costly than looking up the information at the library. However, you decide to use the new methodology because:
- You want to impress your boss.
 - It moves Enbridge closer to its environmental goal of a Triple Bottom Line.
 - The increased testing costs are within the budgetary limitations set by the project maintenance plan.
 - Relying on an internationally recognized standard-setting organization demonstrates due diligence.
- ✓ 33. As the design engineer working on the capacity expansion of an oil refinery in Sarnia, you have identified two feasible alternatives: (1) building three new distillation units on the existing property; or, (2) re-commissioning a nearby refinery that had been closed and trucking the crude oil from the existing property to the re-commissioned refinery. The local municipality favours Alternative (1) because it will bring construction jobs to the community. The Ontario Trucking Association favours Alternative (2) because it will mean work for haulers. Friends of the Earth Canada, a non-governmental organization, opposes both alternatives and wants you to look at biorefining. What can you do to resolve the conflicting interests of these stakeholders?
- Ignore them; your client is the refinery and their interest is the most important.
 - Conduct a break even analysis of the two alternatives and show all the stakeholders that the preferred alternative is the one with the least cost.
 - Determine the relative importance of the influence of each category of stakeholder and then use a ranking and weighting method to identify the preferred alternative.
 - Change the performance targets to emphasize property values, air pollution, and crude oil prices, and re-evaluate the alternatives.

End of Questions pertaining to Case Study #1: Enbridge Line 9B located in the appendix of this exam.

- ✓ 34. A key question about audience to ask when preparing a presentation is:
- a. How can I get all the material I want to talk about into the time limit?
 - b. What assumptions can I make about what the audience already knows?
 - c. What is the most dramatic language possible to present this data?
 - d. What is the audience going to think of me, personally, when I am speaking?
- ✓ 35. The three factors that influence how effective your communication are, in order of importance, from most to least important:
- a. Words, tone, technical level.
 - b. Body language, technical level, tone.
 - c. Body language, tone, words.
 - d. Technical level, words, body language.
- The design should transport mass.
- ✓ 36. Which of the following statements is **TRUE**?
- a. Functions are adjectives describing what the design must be.
 - b. Objectives are verbs describing what the design must be.
 - c. Secondary functions are adjectives resulting from the primary function.
 - d. Functions are verbs describing what the design must do.
- F = should do objective = Should be
- ✓ 37. Recently, owners of a particular model of vehicle manufactured by GM, the Chevy Cruze, have complained that the car does not get as many kilometres to the litre of gas as was promised by the manufacturer. They claim they were misled. The manufacturer says, in its defense, that many factors can affect fuel consumption, including driver behavior and road conditions. Some consumer advocates blame Canadian testing standards, saying that they are not as rigorous as those in the US. In fact, the Canadian government department responsible for tests is planning to introduce new tests by 2015. Which of the following statements, in relation to this issue, is both true and valid?
- a. Car manufacturers should conduct the tests; then if they are not accurate, at least the consumer can sue the manufacturer.
 - b. Governments are unbiased and so they should supervise all testing; that way the standards will be fair to consumers.
 - c. The fact that new tests are being introduced implies that the previous tests did misinform the public.
 - d. The public has to get over the idea that tests are applicable to every case and accept it when things turn out differently.