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### **General Instructions**

- This exam is to be completed in a bluebook – answers not recorded in a bluebook will not be graded.
- Place the exam sheets on the inside of your bluebook when finished and hand them in back with the bluebook.
- Put your name on both your blue book and the exam sheet.
- Show your work step-by-step.
- Write legibly, and state any necessary assumptions.
- If you have a question during any portion of this exam, raise your hand & speak privately to the proctor.

### **Questions:**

1. [15 points] Define following terms in relation to construction project management:

A) Contra Preferentum

**Ambiguities in contracts are generally weighted in favor of the parties that did not draft the contract. E.G. whomever drafted the contract is generally held to a higher standard than other parties.**

B) Liquidated Damages

**Liquidated damages are a form of payment from the contractor to the owner in the event that the project does not meet the required completion date. LD's are based on real, actual costs to the owner related to financing, opportunity costs, etc.**

C) Promissory Estoppel

**Typically is applied when bids are accepted for construction projects. It allows a party to recover on damages even though there might not be a full enforceable contract between the two parties (e.g. competence, consideration, reliance, etc.). Generally, one party has relied upon the promise of another party to his/her detriment.**

D) Bid Shopping

**The practice of accepting subcontractor bids for a prime contract, winning that contract, and then using that sub's bid to leverage other parties to give you a lower price. This is an unethical practice. This can occur at all levels of the project hierarchical structure and work its way up.**

2. [20 points] Your organization has decided to install onsite power generation at one of your industrial sites in California. After consulting with vendors and a few project managers, you

have narrowed down your options to three qualifying systems. Which of the three systems is the best allocation of resources for your organization given an MARR of 10%?

	High Temperature Fuel Cell	Micro Turbine	Reciprocating Engine
<b>Installation</b>	\$(1,500,000)	\$(700,000)	\$(800,000)
<b>Savings year 1</b>	\$450,000	\$250,000	\$225,000
<b>Savings year 2</b>	\$450,000	\$250,000	\$225,000
<b>Savings year 3</b>	\$450,000	\$250,000	\$225,000
<b>Savings year 4</b>	\$450,000	\$250,000	\$225,000

**Note: The question was written such that you did not necessarily have to check that every single option was viable before using the challenger defender method to screen projects.**

**First: Check lowest cost option to the do nothing Scenario:**

$$\begin{aligned}
 PW_{\text{mt-do nothing}} &= -\$700,000 + \$250,000(P/A, 10\%, 4) \\
 &= -700,000 + 250,000(3.170) \\
 &= \$92,000 \text{ (MT Passes)}
 \end{aligned}$$

**Now compare the incremental from MT to Reciprocating Engine**

$$\begin{aligned}
 PW_{\text{RENG-MT}} &= -\$100,000 + -\$25,000 (P/A, 10\%, 4) \\
 &\text{Clearly, this is a bad investment, so we reject the RENEG}
 \end{aligned}$$

**Now compare the incremental from the HTFC to the MT**

$$\begin{aligned}
 PW_{\text{HTFC-MT}} &= -\$800,000 + -\$200,000 (P/A, 10\%, 4) \\
 PW_{\text{HTFC-MT}} &= -800,000 + 200,000(3.170) \\
 &= -\$166,000
 \end{aligned}$$

**Therefore, the Microturbine is your best option.**

3. [20 points] You've decided to try out your new knowledge, and create a CPM schedule for making your breakfast. Your average breakfast consists of Pancakes, Bacon, Eggs, Orange Juice, Coffee and Yogurt with honey, and you make your breakfast according to the following Tasks:

- First you retrieve all of your ingredients from the cupboard and refrigerator.
- You start boiling water for coffee, and making the pancake batter (assume they can start at the same time)
- After the batter is mixed, you get the griddle and pan out.
- You start the first batch of Pancakes after you make some coffee so you can wake up and avoid burning the pancakes if you nod off to sleep.
- Once the first batch of Pancakes is done you start cooking the bacon in the griddle, and the eggs in the pan.
- Once the bacon is done, you can start a second batch of pancakes in the griddle, which should be done cooking at most 10 minutes **after** you start eating (Finish-Start with a lag of 10)
- Once the eggs are done, you get your Yogurt and Orange Juice ready.
- Eat.

Activity	Duration
Get Ingredients	5 minutes
Get Griddle and Pan	1 minutes
Make Pancake Batter	8 minutes
Boil Water	7 minutes
Make Coffee	5 minutes
Make a Batch of Pancakes	5 minutes
Make Bacon	8 minutes
Make Eggs	3 minutes
Get Yogurt and Juice	2 minutes
Eat Food	20 minutes

- [10 points] Draw out an AON network. Use the same conventions as the homework and start at  $t=0$ .
- [5 points] What is the critical path and duration for this schedule?

**Critical Path is: Get Ingredients – Boil Water – Make Coffee – Make First Batch of Pancakes – Make the Bacon – Eat**

**This has a duration of 50 minutes.**

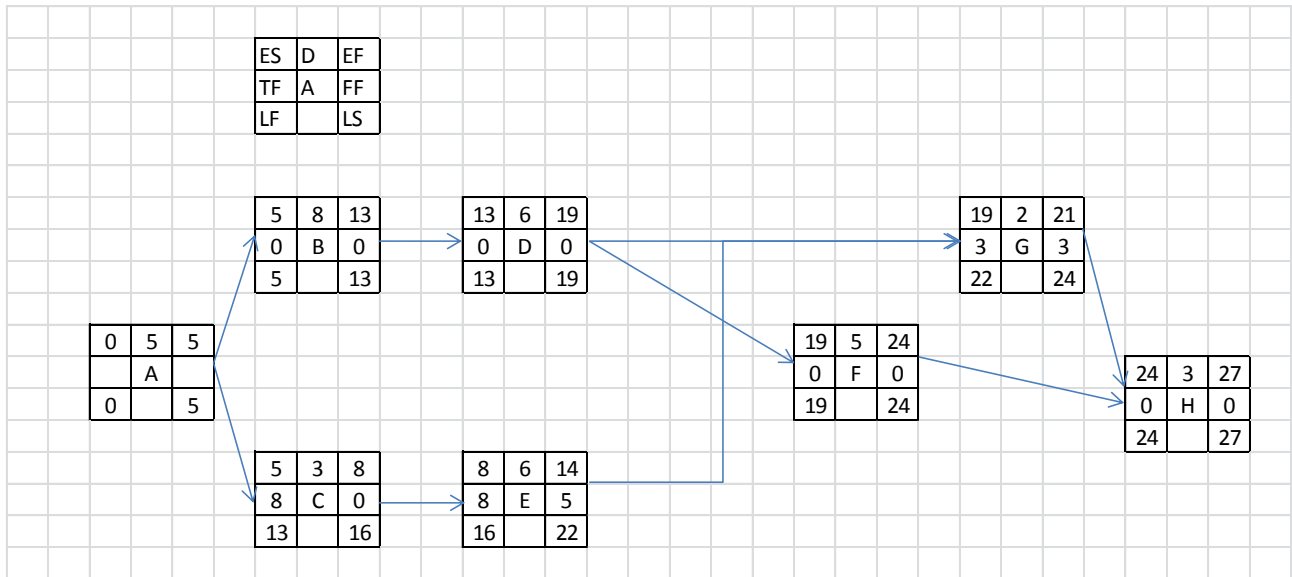
- c. [5 points] Suppose you can buy an automatic coffee maker that will shorten the total amount of time it takes to make coffee from 12 minutes (boil water & make coffee) to 5 minutes. What impact does this have to the total amount of time it takes to make and eat breakfast, and what is your new critical path?

**See the Solutions Supplement.**

**New Critical Path is: Get Ingredients – Make Pancake Batter – Get Griddle and Pan – Make First Batch of Pancakes – Make the Bacon – Eat**

**New Duration is 47 minutes.**

4. [30 points] Given the Following Network:



Activity	Resources
A	5
B	7
C	4
D	3
E	2
F	5
G	3
H	6

- a. [5 points] Given the above AON network, graph the resource levels for the early start schedule. Clearly indicate on your resource graph which activities are on the critical path.

**See Solutions Supplement**

- b. [10 points] Level resources to a maximum of 8 units/day. Do not split activities, change the duration of any tasks or delay the project completion date.. Please graph your results and clearly mark which activity(s) has been shifted.

**See Solutions Supplement**

- c. [10 points] Given that overhead is 100 dollars per day, and the following table of costs, minimize the project duration while also minimizing total cost (complete independently of parts a and b).

Activity	Original Cost	Cost to Crash First Day	Cost to Crash Second Day
A	350	80	90
B	400	30	40
C	150	50	80
D	700	70	110
E	350	40	60
F	600	40	45
G	300	60	---
H	500	80	---

**See the solutions supplements. Only activities along the initial critical path are crashed.**

- d. [5 points] Now add a SS=14 Relationship between activities A and C. What happens to the critical path?

**The critical path now shifts to A-C-E-G-H**

5. [15 points] A solid waste gasifier that produced 300,000 cubic feet of gas per day was installed in Los Angeles in 2000 for a final installed cost of \$4,000,000. You are considering installing a similar system at a dairy in Santa Rosa in 2011 that will produce 500,000 ft<sup>3</sup>/day. Create a preliminary estimate given the following criteria:

- The city cost index for Los Angeles is 107.0, and the cost index for Santa Rosa is 113.9
- The permitting process in Los Angeles cost an additional \$100,000 in 2000 dollars.
- Inflation between 2000 and 2011 will average 3% per year.
- Cost Capacity factor for this plant is 0.6
- Foul weather in Santa Rosa means a 10% chance that there will be \$250,000 of storm damage.
- Better scrubbing equipment will cost an additional \$150,000 in 2011 dollars.

$$[(C_r - C_{\text{permit}}) \times (I_{SR}/I_{LA})(1+i)^n \times (Q_n/Q_r)^x] + C_{\text{scrubbing}} + EV_{\text{storm}}$$

$$[(\$4,000,000 - \$100,000) \times (113.9/107.0)(1+0.03)^{11} \times (500,000/300,000)^{0.6}] \\ + \$150,000 + (0.1 \times \$250,000)$$

$$=\$7,982,702.80$$