3.044 Problem Set 3

Economics of Materials Processing
Due March 2, 2005

Problem 1
For each of the following set of paired alternatives identify whether you would prefer option A, B, or that you are indifferent. For each case, assume a discount rate of 10%.

a) $1000 today vs. $1200 in 2 years

$$PV = \frac{FV}{(1+r)^n}$$

$$PV(\$1000, 10\%, t=0) = \$1000$$

$$PV(\$1200, 10\%, t=2y) = \frac{\$1200}{1.1^2} = \frac{1200}{1.21} = \$992$$

You would prefer the $1000 today

b) $385.54 today vs. $1000 in 10 years

$$PV = \frac{FV}{(1+r)^n}$$

$$PV(\$385.54, 10\%, t=0) = \$385.54$$

$$PV(\$1000, 10\%, t=10y) = \frac{\$1000}{1.1^{10}} = \frac{1000}{2.59} = \$385.54$$

You would be indifferent between the two options

c) Consider the two sets of cash flows represented in the following table

Time Period	Option 1	Present Value Option 1	Option 2	Present Value Option 2
0	-$100	-$100	-$100	-$100
1	$10	$9	$70	$64
2	$30	$25	$50	$41
3	$50	$38	$30	$23
4	$70	$48	$10	$7
Total		$19		$34

You would prefer Option 2.

Problem 2
Compute the value of 10 equal payments which would have the same value as $10,000 received (or expended) today. Assume a discount rate of 8% / period.

$$A = \text{PV} \,?\, r\frac{[(1+\text{r})^{\text{N}}]}{[(1+\text{r})^{\text{N}}-1]}$$

$$A(\$10,000, 8\%, n=10) =$$

$$\$10,000 ?\, 0.08\frac{[(1+0.08)^{10}]}{[(1+0.08)^{10}-1]} = 10k ?\, \frac{0.172}{1.16} = \$1,490$$

Problem 3

Consider a three step process (Process A → Process B → Process C) as described below:

Process Characteristics			
	Cycle Time (sec)	Yield	Equipment Cost
Process A	60	95%	$1,000,000
Process B	90	95%	$500,000
Process C	45	95%	$2,000,000

a) How many units must per processed through A to create a net of 100,000 good parts through the whole process?
b) If it were possible to improve the yield of one process which would have the largest effect on Total process yield? Cost?

The following table can be used to answer a and the second component of b

	Process A	Process B	Process C
Production Volume (Net units produced per year)	110,805	105,264	**100,000**
Effective Production Volume (Gross units processed per yr)	**116,637**	110,805	105,264
Required time per year	1,944	2,770	1,316
Required equipment	0.22	0.32	0.15
Allocated investment	$221,912	$158,112	$300,411
Annual investment	$35,825	$25,525	$48,497
Cost per part	$0.36	$0.26	$0.48
Baseline Total Cost	$1.10		
Total Cost (with 2% improvement)	$1.09	$1.09	**$1.08**
			Largest
			Cost Effect

Regarding the effect on yield, all three processes have the same effect on total process yield, but changes to the last process have the largest effect on total cost.

Problem 4

Consider the polymer extrusion processing described in Problem 4 from problem set #2. In order to ensure proper dimensional control the extrusion must remain on a carefully designed runout table before being cut to length. Assume the following information describing this process.

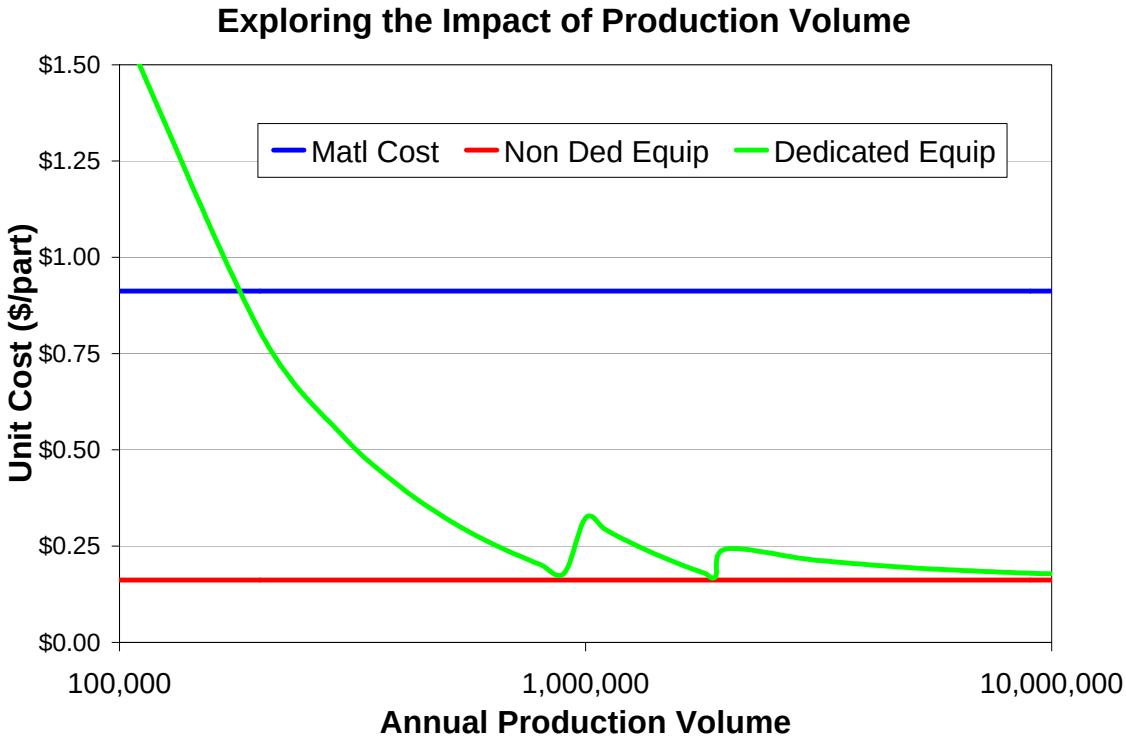
Overall Scenario Description		
Annual Production Goal	1,000,000	good parts
Product Length	3	m
Product Diameter	0.02	m
Extrusion rate	0.1	m/s
Cooling time	20	sec
General financial parameters		
Operating conditions		
Days per year	365	
Hours per day	24	
Discount rate	12%	
Average equipment life	12	years
Processing Characteristics		
Extruded part reject rate	5%	
Cost of extruder	$1,000,000	
Cost per runout	$1,000	$/m
Material Properties		
Density	920	kg/m3
Price	$1	/kg

a) How long of a runout table is required? 2m (answer >2m were accepted too)
b) How much extrusion time is required to meet the production goal? 8,772 hours
c) How many extruders will be required to meet the production goal?
I unintentionally picked a set of numbers that make this answer very close to, but slightly greater than, one(1). Therefore, we will accept either 1 or 2 as correct.

d) Assuming that the only investment involves the extruder and the runout tables, how much capital investment will be required for this facility?
Per above either $1,002,000 or $2,004,000

e) Assuming that this part only pays for the machine time that it uses (i.e., non-dedicated equipment), what will be the cost of equipment per 3m part? What will this figure be if this plant only produces this one part (i.e., dedicated equipment)?
If you worked this out to be 1 extruder in part C then both answers are $0.16/part. If you went with 2 extruders in part C then the answers here are $0.16 and $0.32/part respectively.

f) For an idealized plant (i.e., one with just enough equipment to meet production goals) plot out materials cost, dedicated equipment cost, and non-dedicated equipment cost for the following production volumes: 100,000; 500,000; 1 million and 10 million.



This chart includes more points for better resolution. Notice the impact of introducing a second extruder operating in parallel somewhere around 1,000,000 units. Another shows up at 2e6 units, but is cost effect is damped because it is spread across more units.

g) Polymer supplier ABC has a new material that will allow you to increase extrusion rate by 25%. How much more should you be willing to pay for this new material?

As with any reasonable problem the answer here is that it depends.
If your facility produces no other products (or is not currently fully utilized) and based on our assumptions here of having only Material and Equipment Costs, then an increased extruder speed adds no real value. Actually, you could build a shorter runout table, but that would add less than 1¢ per kg of value.
However, if you do have other products which can be made on this extruder then this new material reduces your time on the extruder at a value which is worth about $0.03 / kg of material.