Ch.E. 453 Fall 2007 Exam #4 Problem #1 12/12/2007

Title : Crude Oil Pipeline Optimum Diameter

	barrels/day	=bpd * 42 gallons/day	=gpd / 24 / 60 gpm	=gpm / 7.481 / 60 ft3/sec	m3/sec	
Flow rate qf	58,000	2,436,000	1691.7	3.768806903	0.1067	
Viscosity, cp	4,900.0	3.2928	lb/ft-sec	=0.000672 * cp	4.90	pascal-sec
Density, Sp. Gravity	0.79	49.05	lb/ft3	=62.4 * Sp.Gr.	785.71	kg/m3

high viscosity fluid = assume laminar; large flow = assume >1" diameter

assume laminar >1" diameter = eqn. 9-78 =0.863 * qf^0.36 * vis^0.18

	meters	inches				old 4th Editi inches
Diameter Opt.	**0.513**	**20.21**	inches	=0.863*(qf^0.36)*(cp^0.18)	=0.863*(F6^0.36)*(C7^0.18)	**22.32**
	0.328	12.92	assume turbulent >1" diameter = eqn. 9-76 =0.363 * qf^0.45 * den^0.13 * vis^0.025			11.753
	0.435	17.11	assume turbulent <1" diameter = eqn. 9-77 =0.49 * qf^0.49 * den^0.14 * vis^0.027			15.198
	0.747	29.40	assume laminar <1" diameter = eqn. 9-79 =1.33 * qf^0.40 * vis^0.20			33.483

Laminar Assumption Reynolds Number Check 35.433

Diameter Opt.	**20.21**	inches	~ ID of nominal 24" diameter steel pipe, Schd. 80	
Velocity	1.69	ft/sec	=qf (ft3/sec) / (PI()* ((d/12)^2)/4)	0.52 m/sec
Re = D V rho / mu < 2100		=	(d inch/ 12 in./ft.)(V ft./sec.)(Den. Lb./ft^3) / Vis. Lb./ft.-sec.	
	42		less than 2,100 thus laminar assumption is valid	
Actual Inside Diameter	**23.25**	inches	nominal 24" diameter steel pipe, Schd. 40	0.59 meters
Velocity	1.28	ft/sec	Table 14-2 recommends Velocity between 3 - 10 ft/sec	0.39 m/sec
Re = < 2100	37		much less than 2,100 thus laminar assumption is valid	

Schedule Assumption Pressure Rating Check = Ch. 12 Eqn. 14: # = 1,000 * psi / 9000 or 1,000 * psi / 6500

Schedule = 111.1 lap-welded 1000/9000 psi

153.8 butt-welded 1000/6500 psi more than 40 thus high strength Sched. 80 is needed

also stainless is stronger than carbon-steel and temperature is well below 250 F limit

Schedule 20 has 0.375" wall thickness, thus Sched. 80 will be ~1" thick

THUS, 20" nominal Schedule 80 will give about 18" inside diameter = too small

THUS, 24" nominal Schedule 80 will give about 21" or 22" inside diameter

	M&S 2002	M&S now	SST 316 factor			old 4th Editi
Fig.12-4	1102.5	1393	1.25			Fig.14-10
0.5m=24"	**$ 3,000** per meter	$4,738	= 3rd Qtr. 2007 cost per meter			**$ 900**
900 miles		1,448,410	meters	$1,444 per foot		900
		$ 6,862,702,629	= purchased cost for 24" pipe			
		6.9	billion dollars			

Ch.E. 453 Fall 2007 Exam #4 Problem #2

Solution Master David C. Drown 12/12/2007

Title : Endowed Scholarship Fund

Given :

July 1, 2006 Endowed Principle	$153,359.55
Total FY 2007 dividends & interest income	$6,383.03
FY 2007 realized capital gains	$4,239.90
Total Returns	$10,622.93
Portion of total distributed	$5,900.00
July 1, 2007 Endowed Principle	$158,082.48

Approach : Calculate Return On Investment from July 1 Principle and appropriate gain

a) Student perspective is $5,900 portion distributed
b) Foundation perspective is $10,623 total return
c) use effective interest equation and solve for i-nominal from answer to a)

Computations :

ROI

a) Student ROI Distributed Return $5,900.00 3.847%
July 1, 2006 Endowed Principle $153,359.55

round off answer = 3.85%

b) Foundation ROI Total Return $10,622.93 6.927% 15.59% 2.25
July 1, 2006 Endowed Principle $153,359.55 10.518% $101,000

round off answer = 6.93%

c) Student nominal nominal ROI 3.7810% compounded 12 monthly
Distributed Return 3.847% = [1 + $i_{nominal}$ / 12] ^{12} - 1
Foundation nominal Total Return 6.927% = [1 + $i_{nominal}$ / 12] ^{12} - 1 6.7162%

on Distributed on Total Return

round off answer = 3.78% 6.72%

Wednesday Friday

Note) Foundation reported these results with statement
"had a strong year, achieving a one-year total rate of return of 15.61%"

Note) Distributed were 8 $750 scholarship awards

Ch.E. 453 Fall 2007 Final Exam #4 Problem #3

Solution Master David C. Drown 12/12/2007

Title : Lysine Fermentation Yield Maximization EVOP

N = 3 variables
Simplex contains N + 1 experiments = 4

	enzymes	Temperature	bacteria	Ave. Yield	Yield1	Yield2	Yield3	Yield4	Yield5
1	3	60	10	4.32	4.19	3.88	4.66	4.56	
2	5	60	10	4.27	4.15	4.45	4.63	3.83	4.29
3	4	66	10	4.47	4.53	3.97	4.62	4.77	
4	4	63	11	4.34	4.33	4.28	4.41		

2.3 **66.0** **10.7** discard lowest Yield = run 2

double the average of 3 best and subtract worst coordinates

2.33 10.67

66.00

=2*((3+4+4)/3)-5

=2*((60+66+63)/3)-60

=2*((10+10+11)/3)-10

possible mistake = **Minimize** instead of MAXIMIZE = backwards move

4.0 56.0 10.7 discard highest Yield = run 3

Student Scores = 24 98.9%

correct = 20 20

other -1 or 2 4 math errors

other -12 or more did not average replicates, not EVOP

maximize -5

correct answers	correct method:
9	2

Maximum	Median	Average	Std. Dev.	Minimum
20.0	20.0	19.8	0.7	17.0

Ch.E. 453 Fall 2007 Final Exam #4 Problem #4 variation of Fall 2007 Exam #2 Problem #3

Solution Master David C. Drown 12/12/2007 Wednesday

Title : Vandal.Con alternatives = evaluate by Present Worth of cash flows at MARR

Given : Interest Rates : MARR 12.90% current ave. 11.75%

Cash Flow : =(net annual)/(1+interest rate)^year

Year	Proposal A	Discounted A	Proposal B	Discounted B	Proposal C	Discounted C	Proposal D	Discounted D
0	$ (69,000)	$ (69,000)	$ (99,000)	$ (99,000)	$ (378)	$ (378)	$ (43,000)	$(43,000)
1	$ 15,000	$ 13,286	$ 19,700	$ 17,449	$ 210	$ 186	$ 17,000	$ 15,058
2	$ 15,000	$ 11,768	$ 19,700	$ 15,455	$ 230	$ 180	$ 28,000	$ 21,967
3	$ 15,000	$ 10,423	$ 19,700	$ 13,689		$ -	$ (43,000)	$(29,880)
4	$ 15,000	$ 9,232	$ 19,700	$ 12,125		$ -	$ 22,000	$ 13,541
5	$ 15,000	$ 8,178	$ 19,700	$ 10,740		$ -	$ 38,000	$ 20,716
6	$ 15,000	$ 7,243	$ 19,700	$ 9,513		$ -		$ -
7	$ 15,000	$ 6,416	$ 19,700	$ 8,426		$ -		$ -
8		$ -	$ 19,700	$ 7,463		$ -		$ -

Approach : Discount each years cash flow at MARR and sum

(a) recognize constant annual cash flows are an annuity & solve A & B with annuity formula
(b) solve C & D by discounting each year and summing

Computations :

Present Worth = = -I + sum[cash flow/(1+0.147)^n] = NPV($E$8,B13:B19)+B12

12.90%	Proposal A	Proposal B	Proposal C	Proposal D
	($2,453.85) ($2,454)	**($4,139.70)** ($4,140)	**($11.55)** ($12)	**($1,598.61)** ($1,599)
	negative PW at MARR	reject B	reject C	negative PW at MARR
	reject A	negative PW at MARR	negative PW at MARR	reject D
	DCFROI or IRR less than 12.9%	IRR less than 12.9%	IRR less than 12.9%	IRR less than 12.9%
	but, better than current average ROI		but, small $ profit PW at MARR	

Recognize constant cash flows = solve with annuity = -I + R*((((1+0.175)^n)-1)/((0.175)*((1+0.175)^n)))

($2,453.85) **($4,139.70)** =D12+D13*((((1+$E$8)^$A$20)-1)/(($E$8)*((1+$E$8)^$A$20)))

Present Worth at current average return interest rate:

11.75%	Proposal A	Proposal B	Proposal C	Proposal D
	$2.46	**($276.75)**	**($5.90)**	**($267.06)**
	accept A	reject B	reject C	negative PW at MARR
	slightly positive PW at MARR	negative PW at MARR	negative PW at MARR	reject D
	IRR barely greater than 11.75%	IRR less than 11.75%	IRR less than 11.75%	IRR less than 11.75%

Direct Cash	$36,000.00	$58,600.00	$62.00	$19,000.00
Internal Rate of Return =	=IRR(B12:B20)			
	11.751%	11.67%	10.58%	11.53%

Ch.E. 453 Fall 2007 Exam #4 Problem #5

Solution Master David C. Drown 12/12/2007

Title : Endowed maintenace cost

Given :

Initial Purchase Investment	$3,500.00
amount invested in endowment fund	$950.00
nominal annual interest rate	4.74%
compounded monthly	12

Approach : Maintenance must be equal to or less than annual interest earned

n = 1, m = 12, i = 0.0473 P = $950

1) compound interest equation: Future = Present * factor

let A = amount of interest earned per period

2) A + P = F = P (1 + i/m)^n*m 2) A = P (1 + i/m)^n*m - P

Computations :

2) A + 950 = F = 950 (1 + 00473/12)^1*12

$46.02

round off answer = $46.00

Ch.E. 453 Fall 2007 Exam #4 Problem #6

Solution Master David C. Drown 12/12/2007

Title : Endowed maintenace cost

Given :

Initial Purchase Cost	$7,900.00	
Installation cost	45.0%	
Annual price inflation	4.0%	
Service life	3	years
Salvage Value factor	5.7%	
Savings account interest rate	6.4%	

Approach : Maintenance must be equal to or less than annual interest earned

Original Installed Cost i = 0.0473 P = $950

1) compound interest equation: Future = Present * factor

let A = amount of interest earned per period

2) A + P = F = P (1 + i/m)^n*m 2) A = P (1 + i/m)^n*m - P

Computations :

Original Installed cost $11,455.00

at time zero Salvage Value $450.30

then installed replaement cost $11,004.70

3

3-year future inflation cost needed $12,378.79

Principle NOW to generate future $10,276.69

replacement year					
6	$13,924.46	$9,596.84			
9	$15,663.12	$8,961.97			
12	$17,618.88	$8,369.10			
15	$19,818.84	$7,815.45			
18	Process Shut down	$7,298.42	**DO NOT INCLUDE in cost**	$22,293.50	
	$90,859.09	**round off answer =**	**$56,475.00**		

including yr 18 salvge credit $56,176.36 $298.64 $912.23

possible mistake = **including yr 18 replacement** $63,773.42

Ch.E. 453 Fall 2007 Exam #4 Problem #7

Solution Master David C. Drown 12/12/2007

Title : Membrane Comparison

Given :

	process	Investment	operating costs
1	bulk N2 gas	$3,200	$28,300
2	liquid N2	$71,000	$31,000
3	membrane 1	$87,000	$27,400
4	membrane 2	$468,191	$233,183
5	membrane 3	$71,600	$9,183
6	membrane 4	$40,600	$11,600
7	membrane 5	$170,000	$95,600
8	membrane 6	$660,000	$440,000
9	membrane 7	$15,000	$179,000
10	membrane 8	$539,833	$148,625

Minimum Acceptable Rate of Return 7.5%

Approach : Incremental Return On Investment analysis

a) rank in order of increasing investment

REJECT any process with operating cost higher than least investment cost alternative

b) calculate incremental savings & incremental investment (why invest more to have negative savings?)

c) calculate incremental ROI

Computations : a) rank in order of increasing investment

compared to process 1, bulk N2 gas:

	process	bid #	Investment	operating costs		delta savings	delta investment	delta ROI
1	bulk N2 gas	1	$3,200	$28,300				
2	membrane 7	9	$15,000	**$179,000**	reject	($150,700)	$11,800	-1277%
3	membrane 4	6	$40,600	$11,600		$16,700	$37,400	45%
4	liquid N2	2	$71,000	**$31,000**	reject	($2,700)	$67,800	-4%
5	membrane 3	**5**	$71,600	$9,183		$19,117	$68,400	28%
6	membrane 1	3	$87,000	$27,400		$900	$83,800	1%
7	membrane 5	7	$170,000	**$95,600**	reject	($67,300)	$166,800	-40%
8	membrane 2	4	$468,191	**$233,183**	reject	($204,883)	$464,991	-44%
9	membrane 8	10	$539,833	**$148,625**	reject	($120,325)	$536,633	-22%
10	membrane 6	8	$660,000	**$440,000**	reject	($411,700)	$656,800	-63%

paired incremental comparison	compare 3 to 1 compare bid 6 to 1	compare 5 to 3 compare bid 5 to 6	compare 6 to 5 compare bid 3 to 5
delta Savings	$ 16,700	$ 2,417	($18,217)
delta Inv.	$ 37,400	$ 31,000	$ 15,400
delta ROI	**44.65%**	**7.80%**	**-118.29%**
	accept	accept	reject
	membrane 4	**membrane 3**	membrane 1

bulk N2 gas

Venture Profit MARR as a cost Analysis:

	membrane 7	membrane 4	liquid N2	membrane 3	membrane 1	membrane 5	membrane 2	membrane 8	membrane 6
MARR Expense	$240	$1,125	$3,045	$5,325	$5,370	$6,525	$12,750	$35,114	$40,487	$49,500
Venture Annual Cost =	$28,540	$180,125	**$14,645**	$36,325	**$14,553**	$33,925	$108,350	$268,297	$189,112	$489,500
	base case		next to smallest cost		smallest cost accept **membrane 3**					
	bid #1	bid #9	bid #6	bid #2		bid #3	bid #7	bid #4	bid #10	bid #8