key

PETE 301

Exam B

October 25, 2004

(Turn in your 2 cheat sheets with your exam. Show your work. Show the units, if appropriate.)

1. (20 points) We want to fit the following gas pressure/production data with the straight line material balance equation: $(p/z) = (p/z)_i\,[1-G_p / G]$. But we want our line to go exactly through the point at $G_p = 0$.

G_p	(p/z)
MMscf	(Bbl/Day)
0	3300
65	2755
217	2410

(a)In the form of a linear equation, $y = b + mx$, identify x, y, b, and m for this problem?

-5 $y = p/z \quad b = (p/z)_i \quad m = (p/z)_i / G \quad x = G_p$

(b) Use the least squares method to calculate the slope of the straight line. What is the initial gas-in-place, G?

Wrong answer — L.S. Fit of 3 points NOT going thru 3300.

-5 $m = \dfrac{n\sum x_i y_i - \sum x_i \sum y_i}{n\sum x_i^2 - (\sum x)^2} = \dfrac{3(702045) - (282)(8465)}{3(51314) - (79524)} = \boxed{-3.776}$

-5 $b = \dfrac{\sum y_i - m\sum x_i}{n} = \dfrac{9529.8}{3} = \boxed{3176.6}$

-5 $G = \dfrac{3176.6}{3.776} = \boxed{840. \text{ MMscf}}$

show work

But this doesn't go thru initial point.

Correct answer.

minimize $\sum (y_i - b - m x_i)^2$; $\dfrac{d}{dm} = \sum 2(y_i - b - m x_i)(-x_i) = 0$

$\sum x_i y_i - \sum b x_i - m \sum x_i^2 = 0$ [note: $b = 3300$]

X 5 $m = \dfrac{\sum xy - b\sum x_i}{\sum x_i^2} = \dfrac{(702045) - 3300(282)}{(51314)} = \boxed{-4.454}$

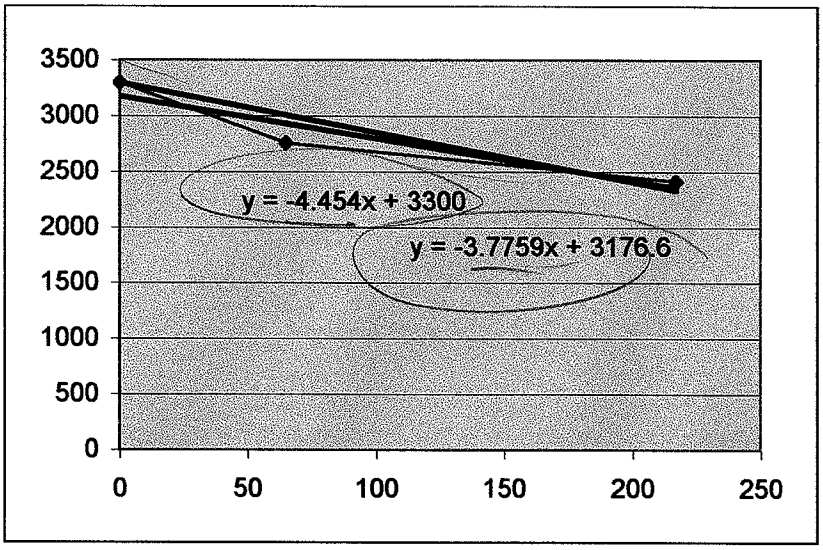
$G = \dfrac{3300}{4.454} = \boxed{740.9}$

m = -4.45405

x Gp	y p/z	xy	x^2	x	y
0	3300	0	0	0	3300
65	2755	179075	4225	65	2755
217	2410	522970	47089	217	2410
	Sums	702045	51314	282	8465

G= 740.907

841.2829

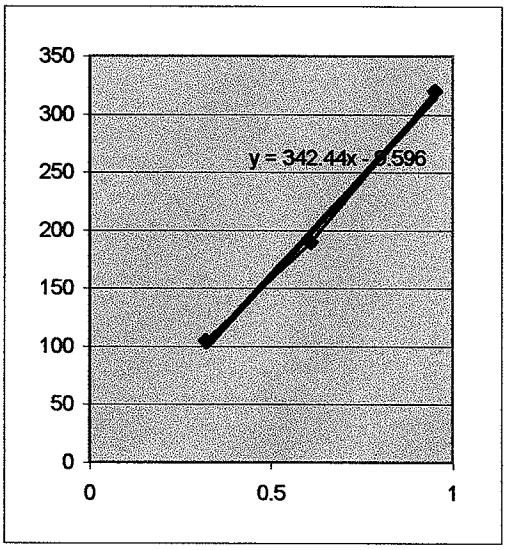


#1

x	y					
dp	q	xy	x^2	x	y	
	0.32	105	33.6	0.1024	0.32	105
	0.61	190	115.9	0.3721	0.61	190
	0.95	320	304	0.9025	0.95	320
	Sums		453.5	1.377	1.88	615

L	5.2
mu	0.95
A	1.45

k = 1.715E+07



#2

2. (20 points) A lab test has been performed on a core sample by flowing water through it and measuring the pressure drop, Δp, and flow rate, q. We know that we can calculate permeability, k(md), from Darcy's law: $q = kA/(14{,}700\ \mu)\ \Delta p/L$. Find a least squares fit of the data and calculate k. Show all the calculations on paper.

Data:	
L, cm	5.2
A, cm^2	1.45
μ, cp	0.95

Flow Data	
q, cm^3/sec	Δp, psi
105	0.32
190	0.61
320	0.950

Least squares fit:

-5 $m = 342.4$

-5 $b = -9.596$

show work

Determine k

$$m = \frac{kA}{14700\,\mu L} = \frac{k(1.45)}{14{,}700(0.95)(5.2)} = 342.4$$

-5 $k = 1.715 \times 10^{7}$

very high k, maybe the core was cracked.

$$m = \frac{3(453.5) - (1156.2)}{3(1.377) - (3.5344)} = 342.4$$

3. (10 points) Suppose we have the following Excel spreadsheet which uses a certain nonlinear equation as a model of y = f(x). Our model uses parameters C1 and C2. We know we can get the best "least squares" fit of the model to the data by using the Excel tool "Solver". When the Solver window pops up, what do you "tell" solver in order to get the best fit. [hint: This is a simple answer. Your answer will contain certain Excel cell locations (such as A1, etc.). You do not have to make any calculations, or figure out what the model is, or change any values by hand. Just mention what information you give to Solver.]

	A	B	C	D
1	Model parameters:	C1 =	5.2	
2		C2 =	162.4	
3	xi	yi	y(xi) from model	Resid^2
4	5.1	420	431.764	138.3917
5	6.4	689	676.944	145.3471
6	7.2	890	855.376	1198.821
7				
8			Sum of resid^2 =	1482.56

-3 -3

minimize D8 (target cell)

by changing C1 and C2

-3 -3

4. (20 points) Consider the ordinary differential equation $y' = \sqrt{x+y}$ with an initial value of y = 0.5 at x = 1. Calculate the value for y at x = 3 using the non-iterative Heun method.

$f(x)$

Euler

$y_{i+1} = y_i + f(x_i, y_i)\, h$

$= 0.5 + \sqrt{0.5+1}\,(2) = \boxed{2.95}$

$f(x_i, y_i) = \sqrt{0.5+1} = 1.22$

Heun

$y_{i+1} = 0.5 + \dfrac{\sqrt{0.5+1} + \sqrt{2.95+3}}{2}(2)$

$= 0.5 + 1.225 + 2.44$

$= \boxed{4.165}$

$f(x_{i+1}, y_{i+1}) = \sqrt{3+2.95} = 2.44$

5. (20 points) The following program is the Runge-Kutta 4th order method to calculate the static pressure drop in a non flowing gas well.

$$\frac{dp}{dD} = \frac{M}{144 R} \frac{p}{zT}$$

(a) Read the required data used in the calculation from worksheet ("Data")
(b) Calculate Runge-Kutta parameters fo, f1, f2, and f3 by calling the pressure_drop function.
(c) Write the calculated pressure at each 300 ft in "Output" worksheet, assuming 300 is a multiple of h.
(d) Will it affect the results if we put the declaration lines before Sub? - 2

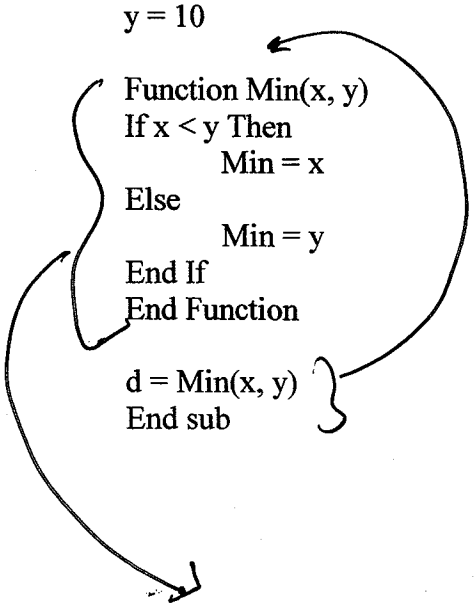
```
Sub pressurecalc()
Dim p As Double, h As Double, initial As Double, final As Double
Dim d As Double, f0 As Double, f1 As Double, f2 As Double
Dim  f3 As Double, pn As Double
Dim i As Integer, j As Integer

'Required input
  .....
  .....
  .....                                    - 5
  .....
  .....
d = initial
pn = p
j = 1                                  'Counter for Output
For i = 1 to (final - initial) / h
  d = d + h
  f0 =  .....
  f1 =  .....                                } - 8
  f2 =  .....
  f3 =  .....
  pn = pn + (h / 6) * (f0 + 2 * f1 + 2 * f2 + f3)

 'Output only every  300 ft
  .....
  .....                                      } - 5
  .....
  .....
  .....
  .....

Next i
End Sub


Function pressure_drop(d As Double, p As Double) As Double      'Function for rk4 steps
   Dim T As Double, z As Double
   T = 298 + 0.071 * d
   z = 1 - 0.102 * (p / 5230000#) + 0.00973 * (p / 5230000#) ^ 2
   pressure_drop = 9.81 * 0.0194 / 8.314 * (p / (z * T))
End Function
```

Pressure - 1

```
'Lab 7 -10/18/04
'This module uses the rk4 method to calculate bottom hole pressure

Sub pressurecalc()

Dim p As Double, h As Double, initial As Double, final As Double
Dim d As Double, f0 As Double, f1 As Double, f2 As Double, f3 As Double, pn As Double
Dim i As Integer, j As Integer

With Sheets("Pressure")              'Required input

    p = .Cells(3, 2)
    h = .Cells(4, 2)
    initial = .Cells(1, 2)
    final = .Cells(2, 2)
    .Cells(3, 4) = initial
    .Cells(3, 5) = p / 1000000#

End With

d = initial
pn = p
j = 1                                                  'Counter for Output

For i = 1 To (final - initial) / h                     'Loop to get pressure at all depths
    d = d + h
    f0 = pressure(d, pn)
    f1 = pressure(d + (h / 2), pn + (h / 2) * f0)
    f2 = pressure(d + (h / 2), pn + (h / 2) * f1)
    f3 = pressure(d + h, pn + (h * f2))
    pn = pn + (h / 6) * (f0 + 2 * f1 + 2 * f2 + f3)
If (d = j * 300) Then                                   'Output only every 300 ft
    j = j + 1
    With Sheets("Pressure")
        .Cells(j + 2, 4) = -d
        .Cells(j + 2, 5) = pn / 1000000#
    End With
End If

Next i

End Sub

Function pressure(d As Double, p As Double) As Double          'Function for rk4 steps
    Dim T As Double, z As Double
    T = 298 + 0.071 * d
    z = 1 - 0.102 * (p / 5230000#) + 0.00973 * (p / 5230000#) ^ 2
    pressure = 9.81 * 0.0194 / 8.314 * (p / (z * T))
End Function
```

6. (10 points) The following program has error; show the error and how you can fix the error

```
Sub calculate()
Dim x As Double, y As Double
x = 5
y = 10

Function Min(x, y)
If x < y Then
        Min = x
Else
        Min = y
End If
End Function

d = Min(x, y)
End sub
```



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