Faculty of Engineering | **Philadelphia University** | Mechanical Eng. Dep.

Engineering Measurements (620344)

Second Exam — **time allowed: 50 min**

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Student Name: **Student ID number:**

Problem #1: for the following experimental data, find the linear fitting equation: y = ax + b using the least square method **(6marks)**

x_i	y_i
1.2	9
1.6	11
1.8	12
2.4	15
3.2	19

$$a = \frac{n\sum x_i y_i - \sum x_i \sum y_i}{n\sum x_i^2 - (\sum x_i)^2} \qquad b = \frac{\sum y_i \sum x_i^2 - \sum x_i y_i \sum x_i}{n\sum x_i^2 - (\sum x_i)^2}$$

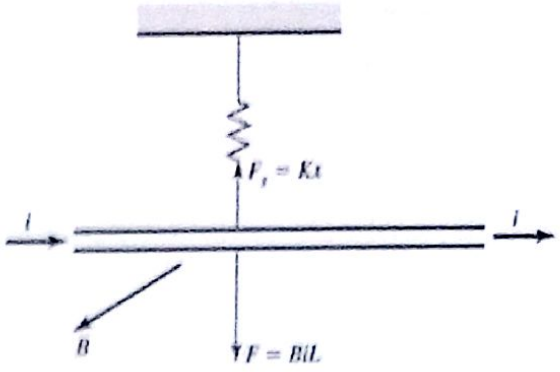
x_i	y_i	$x_i y_i$	x_i^2	
1.2	9	10.8	1.44	$n = 5$
1.6	11	17.6	2.56	
1.8	12	21.6	3.24	
2.4	15	36	5.76	
3.2	19	60.8	10.24	
Σ = 10.2	66	146.8	23.24	

$$a = \frac{(5)(146.8) - (10.2)(66)}{(5)(23.24) - (10.2)^2} = 5$$

$$b = \frac{(66)(23.24) - (146.8)(10.2)}{(5)(23.24) - (10.2)^2} = 3$$

$$y = 5x + 3$$

Problem #2: if the following spring – wire setup is used to measure the current (i). if the spring constant is 550 N/m, the magnetic flux is 365×10^{-3} Weber, the length of the wire is 25cm and the deflection in the spring is 1.6 mm **(4marks)**



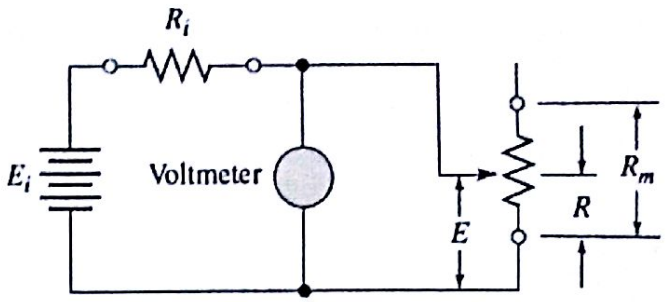
$F_s = F$

$kx = BiL$

$i = \frac{k}{BL} x$

$i = \frac{550}{365 \times 10^{-3} \times 0.25} (1.6 \times 10^{-3}) = 9.64$ ~~12.05~~ Ampere

Problem #3: for the basic electrical circuit shown, if $R_m = 5\Omega$, $R_i = 3\Omega$ the ratio $E/E_i = 0.25$. Find the value of transducer resistance (R) in Ω. **(4marks)**



$$\frac{E}{E_i} = \frac{iR}{i(R_i + R)}$$

$$= \frac{(R/R_m)(R_m/R_i)}{(R/R_m)(R_m/R_i) + 1}$$

Simply

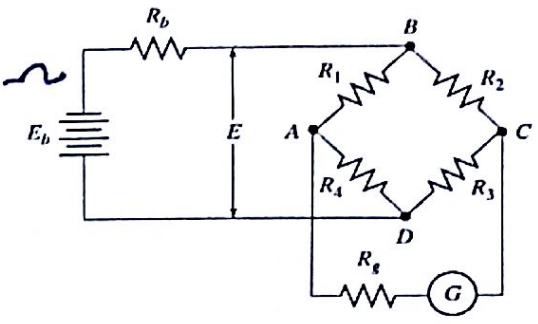
$$0.25 = \frac{R}{3+R} \Rightarrow (0.25)(3) + (0.25)R = R$$

$$\Rightarrow 0.75R = 0.75 \Rightarrow R = 1\,\Omega$$

Problem #4: **(6marks)**

1. Wheatstone bridge circuit has ratio arms (R_2 and R_3) *of 1000Ω and 500 Ω and the adjustable resistance R_1 reads 200Ω.* calculate the value of the unknown resistance R_4 if this bridge is balanced (null condition)

$$R_4 = \frac{R_1 R_3}{R_2} = \frac{(200)(500)}{1000} = 100\ \Omega$$



2. Now, if this bridge is deflected (unbalanced) and a galvanometer with a resistance of 25 Ω and a sensitivity of 0.2 μA/mm is connected between B and D, . The galvanometer deflection is 10 mm, and the battery voltage is 5 V. **assuming no internal battery resistance and the value of R_1 is changed to 280 Ω.** Calculate the value of the unknown resistance R_4

$$i_g = \frac{E_g}{R + R_g} \qquad E_g = E\left[\frac{R_1}{R_1 + R_4} - \frac{R_2}{R_4 + R_3}\right]$$

Subscribe to Find R_4

$$R_4 = \frac{E R_1 R_3 - i_g\left[R_g R_1 (R_2 + R_3) + R_1 R_2 R_3\right]}{i_g (1 + R_1 + R_g)(R_2 + R_1) + E R_2}$$

$$i_g = (0.2)(10) = 2\ \mu A = 2 \times 10^{-6}\ A$$

$$R_b = 0 \quad R_1 = 280 \quad R_2 = 1000, \quad R_3 = 500, \quad R_g = 25$$

$$E = 5\ V$$

$$R_4 = \frac{(5)(280)(500) - 2\times10^{-6}\left[(25)(280)(500+1000) + (280)(500)(1000)\right]}{2 \times 10^{-6}\left[(1+280+25)(1000+500)\right] + 5)(1000)}$$

$$R_4 = \frac{699691}{5000.918} \approx 140\ \Omega$$