Minoufia University Faculty of Engineering Shebin El-Kom First Semester Exam. Academic Year: *2014-2015* Max. Marks. 100		Year: Post Grad. (PhD. Prep.) Dept.: Mechanical Power Eng. Subject: *Mechanical Measurements* Code: *MPE 716* Time allowed: *3 hours* Date: 10/1/2015

Please do not use a pencil to write. (Note: Numbers of Exam. Papers are 3 pages.)

Assume any missing data from your point of view in the limits of what you studied.

Answer all the following questions:

Question-1 **[18 marks]**

Let f(x) be a function of period 2π such that

$$f(x) = \begin{cases} x, & 0 < x < \pi \\ \pi, & \pi < x < 2\pi \end{cases}$$

i) Sketch a graph of *f(x)* in the interval $-2\pi < x < 2\pi$

ii) Show that the Fourier series for *f(x)* in the interval $0 < x < 2\pi$ *is*

$$\frac{3\pi}{4} - \frac{2}{\pi}\left[\cos x + \frac{1}{3^2}\cos 3x + \frac{1}{5^2}\cos 5x + \ldots\right] - \left[\sin x + \frac{1}{2}\sin 2x + \frac{1}{3}\sin 3x + \ldots\right]$$

iii) By giving an appropriate value to *x*, show that

$$\frac{\pi}{4} = 1 - \frac{1}{3} + \frac{1}{5} - \frac{1}{7} + \ldots$$

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Question-2 **[25 marks]**

a) Prove that the Fourier transforms satisfy the inverse Fourier relationship showing its graphical pair for the following time function

$$h(t) = 2Af_0 \frac{\sin(2\pi f_0 t)}{2\pi f_0 t}$$

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b) Discuss briefly three characteristics of the Fourier transform

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Question-3 **[13 marks]**

Discuss in detail basic noise measurement systems

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Question-4 [24 marks]

a) The two resistors R and R_s are connected in series. The voltage drops across each resistor are measured as

$E = 10\ V \pm 0.1\ V\ (1\%)$

$E_s = 1.2\ V \pm 0.005\ V\ (0.467\%)$, ***along*** **with a value of**

$R_s = 0.0066\ \Omega \pm 0.25\%$

From these measurements determine the power dissipated in resistor R and its uncertainty.

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b) A certain obstruction-type flow meter (orifice, venture, and nozzle) showing in the following figure is used to measure the flow of air at low velocities. The relation describing the flow rate is

$$\dot{m} = CA\left[\frac{2g_c P_1}{RT_1}(P_1 - P_2)\right]^{\frac{1}{2}}$$

Calculate the percent uncertainty in the mass flow rate for the following conditions:

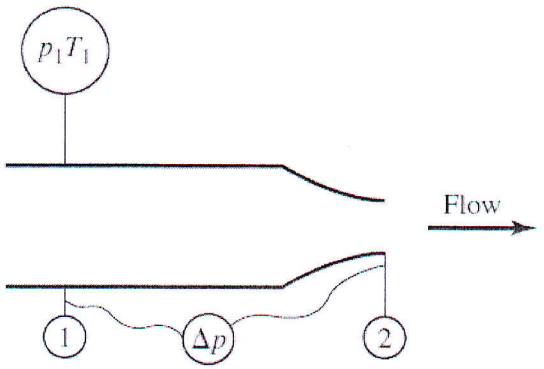
$C = 0.92 \pm 0.005$

$P_1 = 25\ Psia \pm 0.5\ Psia$

$T_1 = 70\ ^oF \pm 2\ ^oF,\ T_1 = 530\ R$

$\Delta P = P_1 - P_2 = 1.4\ Psia \pm 0.005\ Psia$

$A = 1.0\ in^2 \pm 0.001\ in^2$



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c) An inclined manometer with the inclined tube set at *30 degrees* is to be used at *20 °C* to measure an air pressure of nominal magnitude of *100 N/m²* relative to ambient. Manometer ''unity'' oil *(S = 1)* is to be used. The specific weight of the oil is *9770 ± 0.5% N/m² (95%)* at *20 °C*, the angle of inclination can be set to within 1 degree using a bubble level, and the manometer resolution is *1 mm* with a manometer zero error equal to its interpolation error. Estimate the uncertainty in indicated differential pressure at the design stage.

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Question-5 [20 marks]

a) Explain with neat sketches; Photovoltaic Cells – Ionization Transducers.

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b) Explain with neat sketches; Capacitive transducer – Piezoelectric crystal.

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c) A capacitive transducer is constructed of two *1-in*^{2} plates separated by a *0.01-in* distance in air. The dielectric constant for air is *1.0006*. The allowable uncertainty in the spacing measurement is $W_d = \pm 0.0001$ *in*, while the estimated uncertainty in the plate area is ± 0.005 *in*^{2}. Calculate the tolerable uncertainty in the capacitance measurement in order to achieve the allowable uncertainty in the spacing measurement.

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With my best wishes

Prof.dr. Moustafa Nasr