Mansoura University	Final Term Exam	2nd Year Mech. Power
Faculty of Engineering	External (1)	Time: 3 hours
Mech. Power Department	Jan 2013	Measurements and Measuring Devices

Answer the following questions:

Question (1) [31 Marks]

1-(a) Define: Accuracy- Resolution- Dead zone – sensitivity - scale span. [5 Marks]

1-(b) If X is a dependent variable, expressed as $X=f(x_1,x_2)$ drive an expression for the relative limiting error in X, $(\delta X/X)$ as a function of the relative errors in component quantities x_1 and x_2 for the following cases: $X= x_1 + x_2$, $X= x_1^n . x_2^m$. [8 Marks]

1-(c) describe with neat sketches theory of operation of the following devices: [18 Marks]
1- Optical pyrometer for temperature measurement.
2- Fery total radiation pyrometer for temperature measurement.
3- McLeod Gauge for pressure measurement.
4- Moving-coil pickup for velocity measurement.
5- Crystal hygrometer for humidity measurement.
6- Ultrasonic flow meter.

Question (2) [20 Marks]

2-(a) A 50 V range voltmeter is connected across the terminals A and B of the circuit shown in Fig (1). Find the reading of the voltmeter under open circuit and under conditions of load. Find the accuracy and the loading error. The voltmeter has a resistance of 1000 kΩ. [10 Marks]
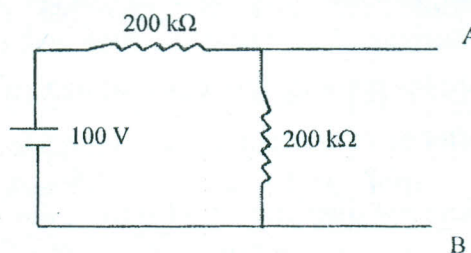

Fig. (1)

2-(b) A thermocouple system has a time constant of 10 s. The system is used to measure the temperature of a furnace, which fluctuates sinusoidally around 620 $^\circ$C with $\pm$ 20 $^\circ$C, with a periodic time of 80 s. Determine the maximum and minimum values of the temperature indicated. Calculate also the phase shift angle and the time lag. [10 Marks]

Question (3) [20 Marks]

3- (a) In an experimental measurement to determine the value of an electrical resistance, the following measurements were obtained: (147.2, 147.4, 147.9, 147.1, 147.1, 147.5, 147.6, 147.4, 147.6, and 147.5 Ω. Calculate (a) arithmetic mean (b) average deviation (c) standard deviation (d) variance (e) probable error. [8 Marks]

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3-(b) The stress in a mild steel flat circular diaphragm is given by:

$$s = \frac{3D^2 p}{16t^2} \quad N/m^2$$

where

D: diameter of the diaphragm, m

t: thickness of the diaphragm walls, m

p: applied pressure, N/m^2

and this diaphragm has a diameter of 15 ±0.3 mm, and a thickness of 0.21 ±1%mm. The pressure applied is 800×10^3 ±1.5% N/m^2. Calculate the stress and included error in the following cases:

(a) The errors are absolute limits,

(b) The errors are uncertainty. **[12 Marks]**

Question (4) [20 Marks]

4-(a) The hot junction of a chromel-alumel thermocouple is connected to a potentiometer whose terminals are at 28°C. The potentiometer reads 25.38 mV. What is the temperature of the thermocouple junction? The calibration chart for the thermocouple as following: **[10 Marks]**

Temperature, °C	20	24	28	....	680	688	693
Voltage, mV	0.8	0.95	1.12	....	26.25	26.72	27.04

4-(b) A manometer uses transformer oil of specific gravity 0.8 as the manometric liquid. However, the scale is graduated in mm of water. If the diameter of one leg is 2 mm and the other is 20 mm, calculate the angle to the horizontal at which the tube and the scale must be inclined to give a reading of 6 mm on the scale for pressure difference equivalent of 1mm head of water. **[10 Marks]**

Question (5) [20 Marks]

5-(a) A rotameter has an internal diameter of 15 mm at the bottom of its range. The float has a specific gravity of 2.6. It has a volume of 550 mm^3, an effective diameter of 10 mm, and a vertical movement of 200 mm. Estimate the range of flow which can be measured using a liquid of specific gravity of 0.8. Also calculate the height of the float in the tube at which the mean flow rate would occur. The angle of taper of the tube is 5°. Assume coefficient of discharge as unity. **[10 Marks]**

5-(b) A Pitot tube with an attached thermometer is used to measure the velocity of air in a duct. A differential pressure of 100 mm of water is recorded. The temperature of the air is 27 °C. The static pressure is 10kN/m^2. The barometer reading is 760 mm Hg. The gas constant is 278 J/kg.K and the specific gravity of Hg is 13.6. The velocity correction factor is 0.95. Calculate the mean velocity of air. **[10 Marks]**

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Answer the following questions: (ملحوظة: تأكد من أن ورقة الأسئلة وجهين مختلفين)

Question (1) [21 Marks]

1-(a) What is meant by the following terms?   **[6 Marks]**
 - Sequence calibration- Fidelity -Time constant - Vena contracta - Limiting error- Pizoelectric effect

1-(b) Discus in details the following: give examples and sketches as possible.   **[10 Marks]**
- The input-output configuration of measuring systems
- The different methods of correction for the interfering and modifying inputs.

1- (c) choose the correct answer   **[5 Marks]**

1- In case of using the inclined manometer, its ....increased when compared with the vertical manometer:
   (a) sensitivity   (b) resolution   (c) accuracy
2- The following transducer may be used (itself) in power control (as a switch):
   (a) bellows   (b) bimetallic   (c) thermocouple   (d) (a) and (b)   (e) all of them
3- In rotameter to eliminate the effect of fluid density the ratio between float density to fluid density should have the ratio ....
   (a) 1   (b) 0.5   (c) 2   (d) 0.25
4- For flow measurement, the following devices are considered variable head types except..........
   (a) venturi meter   (b) orifice meter   (c) Pitot tube   (d) rotameter
5- In the glass thermometer, its sensitivity may be expressed in terms of:
   (a) ^{o}C   (b) mm   (c) mm/^{o}C   (d) ^{o}C /mm

Question (2) [31 Marks]

2-(a) For the following measurement devices **state clearly construction and theory of operation** with **neat sketches**:   **[15 Marks]**

  1- Optical Pyrometer for temperature measurement.
  2- Pirani Gage for pressure measurement.
  3- Electromagnitic flow meter.
  4- Crystal Hygrometer.
  5- Ultrasonic transmitter-receiver for liquid level measurement.

2-(b) State the advantages and disadvantages of: **[6 Marks]**

a- Thermocouple
b- RTD (resistive temperature detector)

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2-(c) A bimetallic strip is to be designed to trip an electric contact. It is to be constructed of invar and yellow brass and must produce a deflection of 1mm at its free end for a temperature variation of 1 °C for the set point of the strip. **Deduce the relationship between the strip length and thickness only L=$f(t)$**, which will accomplish the design objective. Expansion co-efficient of yellow brass is 1.7×10^{-6} per °C. and for invar is neglected. [10 Marks]

Question (3) [28 Marks]

3-(a) If X is a dependent variable, expressed as X=$f(x_1, x_2)$ drive an expression for the relative limiting error in X, ($\delta X/X$) as a function of the relative errors in component quantities x_1 and x_2 for the following cases: X= $x_1 + x_2$,   X= $x_1^n . x_2^m$. [8 Marks]

3-(b) In an experimental test, temperature is measured 100 times with different devices and procedures as shown in the following table:

Temperature, °C	397	398	399	400	401	402	403	404	405
Frequency of occurrence	1	3	12	23	37	16	4	2	2

- What is the type of this sample?
- Calculate: (a) arithmetic mean (b) mean deviation (c) standard deviation (d) probable error of one reading. [10 Marks]

3-(c) Heat transfer from a rod of diameter D immersed in a fluid can be described by the Nusselt number, $Nu=hD/k$, where h is the heat-transfer coefficient and k is the thermal conductivity of the fluid. If $h=150 \pm 5\%$ W/m^2.K, $D=20 \pm 0.5$ mm and $k=0.6 \pm 2\%$ W/m.K. Calculate the nominal value of Nusselt number (Nu) and the related estimated error if:
(a) The given errors are the absolute limits
(b) The given errors are uncertainties [10 Marks]

Question (4) [20 Marks]

4-(a) A mercury manometer is to use a well of 30 mm diameter and a vertical tube of 5 mm diameter. Calculate the distance between the zero and 1 bar scale marks. Is the instrument more or less sensitive than a simple U-tube manometer? [5 Marks]

4-(b) A rotameter has an internal diameter of 15 mm at the bottom, the specific gravity of the float is 2.6, its volume is 550 mm^3, with effective diameter of 10 mm, surface area of 100 mm^2, and a vertical angle of movement of 200 mm. Estimate the range of flow which can be measured using a liquid of specific gravity of 0.8. Also calculate the height of the float in the tube at which the mean flow rate would occur. The angle of taper of the tube is 5°. Assume C_d as unity. [10 Marks]

4-(c) A pizo-electric crystal having dimensions of (5x5x1.5) mm^3 and a voltage sensitivity of 0.055   V m/N is used for force measurement. Calculate the force if the voltage developed is 100 V. [5 Marks]

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