



Final Exam of **Composite Materials** (MDP4128) for  
 4<sup>th</sup> Year Production Engineering and Mechanical Design  
 Date: 13 Jan 2016

Total Marks: 75  
 Time allowed: 3 hrs  
 No. of pages: 2

Answer all the questions. Neat sketches and clear examples are considered a part of your answer

**Q1: Select the most correct answer**

(40 marks)

1. Not classified as a laminated composite: (Bimetal – Sandwich panel – Kevlar® - Plywood).
2. Lining the cylinders of car engine with MMCs increases its (thermal insulation and wear resistance – weight and thermal conductivity – thermal conductivity and wear rate – thermal conductivity and wear resistance).
3. The specific modulus of elasticity of a composite with density,  $\rho$ , Young's modulus,  $E$ , and strength,  $\sigma$ , is given by ( $E/\rho - E/(\sigma\rho) - \sigma/\rho - \sigma^2/\rho - E^2/\rho$ ).
4. An isotropic material is one with (different properties in all directions – same properties in all directions – different properties at different locations – same properties in all locations).
5. Which polymer is the strongest? (Epoxy – Polyethylene – Polyester – Polypropylene).
6. Possesses an outstanding adhesion and is used as a wetting agent for glass fibers: (Vinyl-ester resins – Epoxy resin – Polyester resin – Thermoplastic resin).
7. Suggest a reinforcing material for a composite part that subject to service temperature of 1500°C in an oxidative environment: Silicon nitride ( $\text{Si}_3\text{N}_4$ ) – Alumina ( $\text{Al}_2\text{O}_3$ ) – Graphite – Diamond
8. Highest permeability during infiltration is achieved by the fiber combination:  
 a) Coarse size/high  $f_r$     (b) coarse/low  $f_r$     (c) Fine size/low  $f_r$     (d) Fine size/high  $f_r$
9. Consolidation of prepreg plies increases the volume fraction of the (matrix – fibers – voids – composite).
10. During curing of thermosets, the released heat at the gelation point (starts to decrease – starts to increase – remains constant – reached its peak).
11. Pressure vessels made from PMCs are best fabricated by (compression molding – depression molding – premix injection molding – filament winding – pultrusion) technique.
12. Continuous production of long hollow fiber reinforced epoxy beam is best done using (compression molding – depression molding – premix injection molding – filament winding – pultrusion) technique.
13. Metal powders used for the manufacture of MMC could be produced by (hot isostatic pressing – electron beam deposition – agglomeration – sintering – cosmic rays).
14. The bending strength of a sandwich composite is mainly afforded by the facing (true – false).
15. Foams, wood, and stretched honeycomb aluminum are common materials for the core of the sandwich structure (true – false).
16. Peel-up delamination occurs during drilling laminated composites when the inter-laminar bond strength is insufficient to resist the (thrust – shearing – push-out – pull-out – frictional) force.
17. Cutting a hole in a CMC is best accomplished by the (AWJ machining – electric discharge machining – laser cutting – end mill – electrochemical machining).

18. Tension failure of fastened laminated composite joints is more likely to occur if most of fiber plies are aligned at an angle of ( $0^\circ - 45^\circ - 45^\circ - 15^\circ - 90^\circ$ ) to the load direction.
19. (Epoxy-bonded aluminum foil – Polyurethane – Vapor-deposited Ni – SiO<sub>2</sub>) is not from the protective coatings of the spacecraft parts.
20. Repair of delamination damages using adhesive bonded patches is an example of the (temporary repair – semi-structural – full strength – non-structural) repair.

**Q2: Give short notes about the following issues:**

(3+4+3= 10 marks)

- Pre-compounded composite reinforcement “Prepreg”.
- Permeability, pressure gradient, and viscosity as parameters that control the infiltration of fibers.
- Effect of various fluids on the performance of composites.

**Q3: With the aid of neat sketches explain:**

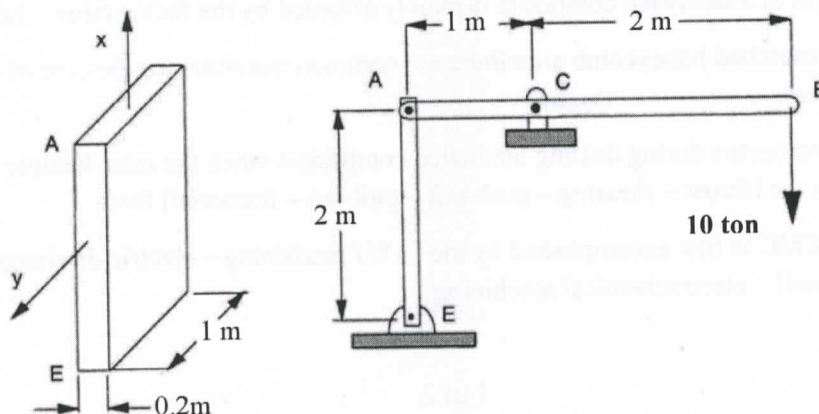
(3+3+4= 10 marks)

- Vacuum molding as a fabrication technique for PMCs.
- Three different methods to treat the ends of sandwich panels with honeycomb core.
- How delamination failure develops by over loading of laminated composite (i) single, and (ii) double lap adhesive joints.

**Q4:**

(4+11 = 15 marks)

- Derive a correlation to calculate the modulus of elasticity of long fiber reinforced composite material in the direction i) parallel to fibers, and ii)  $90^\circ$  to fibers' direction.
- A rigid beam AB is pinned at C, and connected to long-fibers composite column at A by a pin. The dimensions of the composite column and the beam AB are shown in the figure below. A mass of 10 ton hanged at B causes an elastic elongation of 0.1 mm in the column AE. Given that the Young's modulus of elasticity for the fiber and matrix materials are 200 and 5 GPa respectively. Find the following:
  - The tensile stresses in each of the composite column, the fibers, and the matrix.
  - The X-Young's modulus of the column material.
  - The fiber content in the composite column.
  - The Y-Young's modulus of elasticity of the column material.
  - The mass of the composite column, given that the densities of the fiber and matrix are  $7.6 \text{ g/cm}^3$  and  $3.2 \text{ g/cm}^3$  respectively.



Best wishes,  
Assoc. Prof. Mahmoud Ahmadein



**PROBLEM # THREE (35%)**

Draw the G-Code below with scale 1:1

1	G90	43	G01 Z-5.0000
2	G01 Z5.0000	44	G01 X157.0000 Y15.0000
3	G00 X10.4833 Y0.0000	45	G01 X164.0000 Y15.0000
4	G01 Z-2.5000	46	G01 X164.0000 Y15.0000
5	G01 X10.4833 Y104.0000	47	G03 X164.0000 Y90.0000 I0.0000 J37.5000
6	G01 X42.0000 Y104.0000	48	G01 X157.0000 Y90.0000
7	G01 X42.0000 Y104.0000	49	G01 Z5.0000
8	G02 X63.4866 Y58.0465 I0.0000 J-28.0000	50	G00 X164.0000 Y105.0000
9	G02 X42.0000 Y0.0000 I-21.4866 J-25.0465	51	G01 Z-5.0000
10	G01 X42.3150 Y0.0000	52	G02 X164.0000 Y-0.0000 I0.0000 J-52.5000
11	G01 X10.4833 Y0.0000	53	G01 X164.0000 Y0.0000
12	G01 Z5.0000	54	G01 X139.0000 Y0.0000
13	G00 X28.4833 Y15.5000	55	G01 X139.0000 Y105.0000
14	G01 Z-2.5000	56	G01 X164.0000 Y105.0000
15	G01 X42.0000 Y15.5000	57	G01 Z5.0000
16	G03 X42.0000 Y50.5000 I0.0000 J17.5000	58	G00 X63.4866 Y58.0465
17	G01 X28.4833 Y50.5000	59	G01 Z-5.0000
18	G01 X28.4833 Y15.5000	60	G02 X42.0000 Y0.0000 I-21.4866 J-25.0465
19	G01 Z5.0000	61	G01 X42.3150 Y0.0000
20	G00 X28.4833 Y64.0000	62	G01 X10.4833 Y0.0000
21	G01 Z-2.5000	63	G01 X10.4833 Y0.0000
22	G01 X28.4833 Y89.0000	64	G01 X10.4833 Y104.0000
23	G01 X42.0000 Y89.0000	65	G01 X42.0000 Y104.0000
24	G02 X42.0000 Y64.0000 I0.0000 J-12.5000	66	G01 X42.0000 Y104.0000
25	G01 X28.4833 Y64.0000	67	G02 X63.4866 Y58.0465 I0.0000 J-28.0000
26	G01 Z5.0000	68	G01 Z5.0000
27	G00 X139.0000 Y105.0000	69	G00 X42.0000 Y64.0000
28	G01 Z-2.5000	70	G01 Z-5.0000
29	G01 X164.0000 Y105.0000	71	G01 X28.4833 Y64.0000
30	G02 X164.0000 Y-0.0000 I0.0000 J-52.5000	72	G01 X28.4833 Y64.0000
31	G01 X164.0000 Y0.0000	73	G01 X28.4833 Y89.0000
32	G01 X139.0000 Y0.0000	74	G01 X42.0000 Y89.0000
33	G01 X139.0000 Y105.0000	75	G02 X42.0000 Y64.0000 I0.0000 J-12.5000
34	G01 Z5.0000	76	G01 Z5.0000
35	G00 X157.0000 Y90.0000	77	G00 X42.0000 Y50.5000
36	G01 Z-2.5000	78	G01 Z-5.0000
37	G01 X157.0000 Y15.0000	79	G02 X42.0000 Y15.5000 I-0.0000 J-17.5000
38	G01 X164.0000 Y15.0000	80	G01 X28.4833 Y15.5000
39	G01 X164.0000 Y15.0000	81	G01 X28.4833 Y50.5000
40	G03 X164.0000 Y90.0000 I0.0000 J37.5000	82	G01 X42.0000 Y50.5000
41	G01 X157.0000 Y90.0000	83	G01 Z5.0000
42	G01 Z5.0000		



Production Engineering & Mechanical Design  
Department



Tanta University

Final-Term Exam (90 Marks)

Faculty of Engineering

Course Title: Metrology

Date: 18-1-2016

Year: 4<sup>th</sup> Production Eng. Dept.

Course Code: MPD4126

Allowed Time: 3 Hrs.

No. of Pages: (4)

أجب عن جميع الأسئلة ( الأسئلة في أربع صفحات )

**Question 1: [20 marks]**

- a- Define the following terms: *measurand*, *reading*, *true value*, and *calibration*.
- b- A  $\Phi 45_{-0.03}^{+0.05}$  mm hole is to be drilled in a steel workpiece. If the hole tolerance will be checked by a plug gage,
- Find the nominal dimension and the suitable tolerance value for both Go, and No-go sides of the plug gage.
  - For both Go, and No-go sides -and with the aid of sketch-, assign the tolerance value with respect to the nominal dimension according to the *unilateral* tolerance system and the *bilateral* tolerance system.
- c- Figure (1) shows a portion of a liquid-in-glass thermometer's scale جزء من تدريج ثرمومتر زجاجي مملوء بسائل. If the shown thermometer has a linear scale (equal divisions) in degree Celsius ( $^{\circ}\text{C}$ ), determine the **sensitivity**, and **resolution** of the thermometer. Also, calculate the **standard uncertainty due to resolution الناتجة عن** for the shown thermometer.

**Question 2: [15 marks]**

- a- Show by **sketch only**: (وضح بالرسم فقط)
- The construction of the strain gage.
  - The construction of the resistance thermometer.
  - The practical pressure thermometer.
- b- A  $\Phi 30_{-0.10}^{+0.00}$  mm shaft was to be manufactured on a center-lathe machine. At the inspection stage, the final turned diameter was measured using a digital caliper to check its compliance with the specified tolerance. The measurement procedure was repeated 10 times, and the readings were as listed below. If the caliper's resolution is 0.01 mm and its calibration uncertainty is 0.1 percent of the reading with coverage factor  $k=2$ ,
- Estimate the uncertainty budget and summarize it in the tabular form.
  - With the aid of a neat sketch, show the compliance of the product with the specified tolerance.

$i$	1	2	3	4	5	6	7	8	9	10
$\Phi$ (mm)	29.96	29.95	29.97	29.93	29.97	29.96	29.94	29.95	29.97	29.96

**Question 3: [15 marks]**

a- Show by **sketch only**:

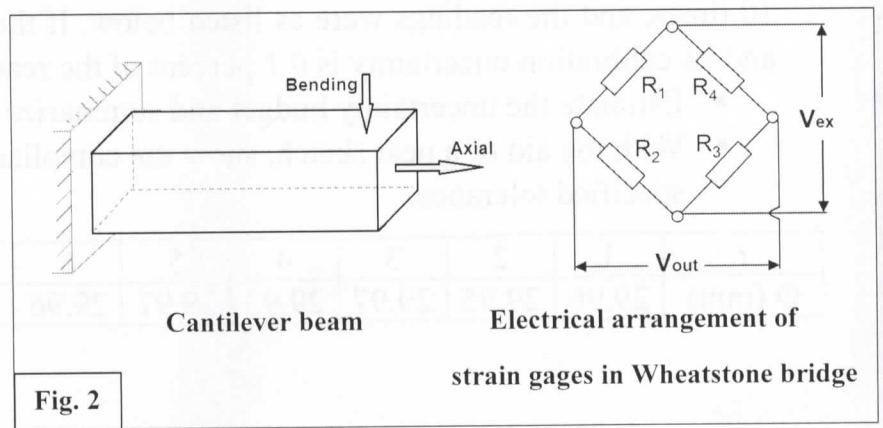
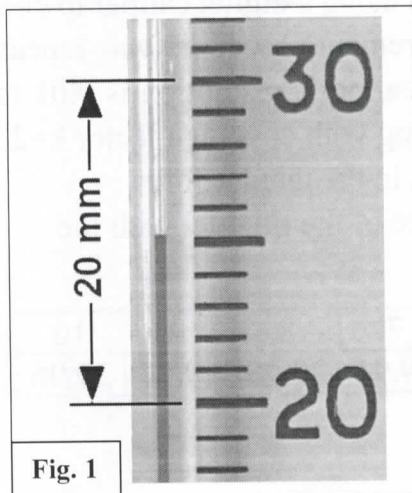
- Bourdon tube in measuring pressure.
- The various forms of thermistors.

b- A steel bar with uniform square cross-section ( $30 \text{ mm} \times 30 \text{ mm}$ ) is subjected to a uniaxial load beyond قبل the yielding point. To measure the load, four strain gages were positioned on the bar to form a full Wheatstone bridge (*measure axially and reject bending*) with sensitivity  $1.30 \text{ mV/V}$  at  $1000 \text{ microstrain}$ . The bridge was energized by a  $10 \text{ V}$  stable DC power source, and its output was amplified using a precision instrumentation amplifier (gain factor =  $500$ ). If the modulus of elasticity of steel  $E = 200 \text{ GPa}$ , and the measured amplified bridge-output corresponding to the load المناظر للحمل was  $5 \text{ V}$ , what is the value of the load? (Note:  $1 \text{ GPa} = 10^9 \text{ N/m}^2$ )

**Question 4: [20 marks]**

- a- Illustrate with neat sketches the purpose of connecting thermocouples in series and in parallel.
- b- Illustrate with a neat sketch the usage of comparator in determining the precise diameter of a plug gage.
- c- The cantilever beam shown in figure (2) is subjected to both axial and bending loads. To measure the strain on the beam, four identical متماثل strain gages ( $R_1, R_2, R_3,$  and  $R_4$ ) are available at your disposal تحت تصرفك. By using the correct number of strain gages, **explain by sketch only** how these strain gages can be positioned on the beam to form the following bridge configurations:
- A quarter-bridge, sensitive to both axial and bending loads (with temperature compensation تعويض تأثير درجة الحرارة).
  - A half-bridge, sensitive to bending load only.
  - A full-bridge, sensitive to axial load only.

**Note:** consider the electrical arrangement of strain gages shown in figure (2)



**Question 5: [20 marks]**

For each question, choose the correct answer from the multiple-choice list

( اختر إجابة واحدة فقط لكل سؤال )

- 1- Any measurement error whose value is unknown is considered as a source of .....
- (a) tolerance  
(b) operator error  
(c) uncertainty  
(d) none of the above
- 2- If the value of an absolute pressure  $p = +100$  mmHg measured at the sea level تم قياسها على نفس مستوى سطح البحر, then  $p$  is a .....
- (a) negative gage pressure  
(b) positive gage pressure  
(c) vacuum pressure  
(d) both a, and c
- 3- The wear allowance may be applied to the *Go side* of the plug gage to .....
- (a) decrease the gage cost  
(b) increase the gage lifetime  
(c) facilitate يسهل the relative motion between gage and hole  
(d) prevent the operator errors
- 4- In *Dead-weight tester* the force is generated تتولد using a calibrated ..... subjected to a known value of gravity.
- (a) sensor  
(b) mass  
(c) flat diaphragm  
(d) Bourdon tube
- 5- *Bimetal temperature-sensing elements* depend on the difference in ..... between the two metal elements to sense temperature changes.
- (a) densities  
(b) cross sections  
(c) thermal expansion coefficients  
(d) thermal coefficients of resistivity
- 6- The *class* of a set of gage blocks specifies يحدد its .....
- (a) tolerances  
(b) thickness range  
(c) material type  
(d) surface hardness number
- 7- For a strain gage, the ratio of its resistance change to strain change is known as .....
- (a) resistivity  
(b) sensitivity  
(c) gage factor  
(d) output-to-input ratio

8- LVDT converts the ..... into a proportional electric voltage.

- (a) temperature
- (b) stress
- (c) static pressure
- (d) displacement

9- The displacement amplification method used in the *inclined-type manometer* aims to .....

- (a) increase the measuring range
- (b) decrease the manometer cost
- (c) increase the measuring sensitivity
- (d) both a, and b

10- *Stylus* can't always follow the true surface contour due to .....

- (a) the friction effect
- (b) the stylus-tip radius
- (c) the limited extension length طول الأنبساط of the scriber ( أداة تتبع شكل تضاريس السطح ) المخّطاط
- (d) both b, and c

11- *Strain gage rosettes* are commonly used to determine .....

- (a) uniaxial *compressive* strain
- (b) uniaxial *tensile* strain
- (c) both uniaxial *compressive*, and *tensile* strains
- (d) *principal* strains

12- Pressure can be converted into strain by applying the pressure to a .....

- (a) strain gage
- (b) flat diaphragm
- (c) Bourdon tube
- (d) none of the above

13- The average change in thermocouple output signal per degree Celsius is in the range .....

- (a)  $< 100 \mu\Omega$
- (b)  $< 100 \mu V$
- (c)  $> 100 \mu\Omega$
- (d)  $> 100 \mu V$

14- *Thermocouples* have many advantages except ما عدا .....

- (a) the rapid response
- (b) the wide واسع measuring range
- (c) no need for عدم الحاجة لـ an external excitation power source
- (d) no need for a complex signal conditioning circuit

15- In *piezoelectric pressure transducers*, pressure is sensed by detection of the ..... on the stressed مجهّد quartz columns.

- (a) resistance
- (b) strain
- (c) temperature
- (d) charge