Reg. No.



MANIPAL INSTITUTE OF TECHNOLOGY

## V SEM B.Tech.(BME) DEGREE END SEMESTER EXAMINATIONS NOVEMBER 2017 SUBJECT: BIOMATERIALS AND PROSTHETICS (BME 3103) (REVISED CREDIT SYSTEM)

Friday, 17<sup>th</sup> November 2017: 2 PM to 5 PM

## TIME: 3 HOURS

MAX. MARKS: 100

## **Instructions to Candidates:**

## 1. Answer All questions.

2. Use separate answer book for Biomaterials (Q.1-3) and Prosthetics (Q.4-5)

- 1A. Differentiate 'creep' and "relaxation" behavior in the context of viscoelastic model of a material? Using a spring and Newtonian dashpot, derive an expression for the viscoelastic behavior of bone applies to Maxwell model.
- 1B. A bioengineer is trying to understand the biomechanics of a hole created in the skin for transcutaneous transplants. He excised out the skin of a dog with and without the hole and put on a tensile testing machine (the width and gage of the samples were 4 cm and 4 mm, respectively.

(i) If the average forces recorded after straining 30% for the samples with and without the hole were 100 and 160 N, what are the respective values of the stress?

- (ii) Calculate the percentage change in stress by making the hole.
- **1C.** Explain the steps involved in investment casting.

4

- 2A. You are asked to design a composite material from collagen and hydroxyapatite for designing scaffold in bone tissue engineering. The values of the modulus of hydroxyapatite and collagen are 100 GPa and 10 GPa respectively. What volume of collagen will be required to make the modulus of the composite plate 100 GPa? Assume that the fibers are aligned in the direction of the test and V<sub>resin</sub>+V<sub>fibers</sub>=1.
- **2B.** (i) Analyze the pros and cons of cemented and cementless fixation process. **5**

(ii) Highlight the limitations of PMMA as a bone cement.

- **2C.** Discuss the steps involved in the fixation of total hip arthoplasty. Compare **6+4** endosteal and subperiosteal dental implants.
- 3A. Why the implantation of mixed metals (dissimilar metals) is usually 4 avoided? Explain.
  Analyze the impact of 'central blood flow' on the stability of a mechanical heart valve.

- **3B.** Compare (i) laminar and sandwich model of structural composites, (ii) 316 **6** and 316L stainless steel,(iii) calcined and tabular alumina.
- **3C.** Explain the effects of the following factors on the properties of polymer **10** (mechanical strength).

(i) molecular weight, (ii) side chain substitution, (iii) crosslinking, (iv) glass transition temperature.

4A. (i) Using appropriate diagrams, explain the function of each of the major 6+2+4 parts of a hemodialysis machine and the normal dialysis process in a patient.

(ii) In what way is Hemofiltration different from Ultrafiltration. Be specific in your answer, and clearly differentiate the two processes.

(iii) Draw the molecular weight cut off diagrams (molecular mass vs clearance) for high-flux and low-flux membranes, normal glomerular filtration and hemofiltration. Mark the axes and different points on the diagram, clearly.

- **4B.** With suitable diagrams discuss the working of a pulse duplicator. All parts **5** should be clearly labelled and their function should be explained.
- **4C.** In a few sentences, explain the construction of Charnley's prosthesis. Draw **3** a simple diagram and clearly show the parts.
- **5A.** Choose any one of the following topics and, in two or more pages, summarize the need for such a device, physiology behind it, current technologies, clinical and engineering related problems associated with current devices and innovative solutions where appropriate. You need to look at the material aspects, design-feasibility and practicality, biological and engineering problems, and so on. You should also discuss the validation aspects (*in-vitro* and *in-vivo*).

Topics:

1. Wearable kidney, 2. Hemodialysis machine, 3. Peritoneal dialysis machine, 4. Insulin pump, 5. Automated CPR machine, 6. Coronary Stent, 7. Bio-reactor artificial liver system, 8. Extracorporeal circuit for infant open heart surgery, 9. Non-pulsatile blood pump, and 10. Bone lengthening devices

- **5B.** Explain how a disc valve is superior or inferior to Ball and tissue valves. List **4** the points of comparison and then compare in a tabular form.
- **5C.** (i) Compare an External counter pulsator with implanted VAD as cardiac **4+4** assist device.

(ii) Explain the terms 'Diffusion' and 'Convection' in the context of Hemodialysis.