King Saud University
College of Applied Medical Sciences
Biomedical Technology Department

BMT232: Principals of Mechanical Biomedical Instrumentation 3 (2-1-0)

Current Instructor: Eng. Mohammad Shaaban and Dr Mohamed Z. Bendjaballah
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Textbook(s) and/or Other Required Materials: Instructor notes and Handouts
Extra references: *Mechanical Engineering: Shigley's Mechanical Engineering Design,* Budynas−Nisbett, McGraw−Hill, 2006 (8^{th} edition); *Fundamentals of Fluid Mechanics*, B. Munson, D. Young and T. Okiishi, Wiley, 2005 (5^{th} edition); *Mechanics of Solids and Fluids*, Ziegler, F., Springer Verlag, Berlin, 1995 (2^{nd} ed.); *Equipment Therapy for Respiratory Care*, White, G. C., Thomson Delmar Learning, 2005 (4^{th} ed.)

Course Description (catalog): The Part-A of this is course introduces students to continuum mechanics principles. The student should be able to investigate internal forces in systems using free body diagram (FBD) technique with special application on predicting internal forces in the human joints. He should be then able to assess the stresses states induced by such loadings and represent them a stress element. Strain definition and measurement techniques (strain gauges) are also covered. Stress-strain relationships and principal stress/strain components are investigated via Mohr's circle. **The Part-B** focuses on fluid mechanics. Fluid statics principles are first covered stressing the pressure calculation and measurement techniques. Viscous and non-viscous basic fluid dynamic equations are developed and special attention is focused on blood flow in circulatory system as well as application of such principles in medical equipment.
Prerequisites: BMT224
Co-requisite: None
Course Type: Mandatory
Course Learning Outcomes: The global content of the course will:

- Help students understand the basics of continuum mechanics.
- Introduce the concept of free body diagram 'FBD' and its application to graphically estimate the contact forces in human joints
- Develop the ability of students to investigate simple stress and strain states in solids.
- Help students understand the basics of fluid mechanics.
- Show students the application of fluid mechanics principles to simple medical mechanical equipment.

Student Outcomes Covered by Course:
a. an ability to select and apply the knowledge, techniques, skills, and modern tools of biomedical technology to include the application of circuit analysis, analog and digital electronics, microcomputers, biomechanics, biomedical instrumentation systems, and safety in the building, testing, operation, and maintenance of biomedical equipment.
b. an ability to select and apply a knowledge of mathematics, chemistry, physics, and biological sciences, engineering, and technology to building, testing, operation, and maintenance of biomedical equipment and the ability to utilize statistics/probability, transform methods, discrete mathematics, or applied differential equations in support of biomedical systems.
Students apply knowledge in differential and integral calculus in junction with equilibrium

principles to determine the internal forces and thus internal stresses acting on solids. For fluid statics, students use such principles to determine the pressure at any location for compressible and incompressible fluids. For moving fluids, students use the Bernouilli equation to determine flow characteristics as well as pressure loss when applicable in the case of viscous flows

c. an ability to conduct standard tests and measurements; to conduct, analyze, and interpret experiments; and to apply experimental results to improve processes.

Students apply fluid statics principles to manometry and blood pressure measurement using invasive and non-invasive techniques. They also determine the flow characteristics through the flow-meter types and the kinematic and pressure energy measurement experiments. Viscosity measurement of selected fluids is achieved through the falling ball experiment.

d. an ability to analyze, design, and implement biomedical systems, components or processes for broadly-defined engineering technology problems appropriate to program educational objectives.

e. an ability to function effectively as a member or leader on a technical team.

f. an ability to identify, analyze, and solve broadly-defined biomedical technology problems.

Students are able to solve equilibrium equations, determine internal forces in solids using FBD, identify the stress state and draw the corresponding stress element. They are also able to estimate the strains in a point from initial and deformed solid states and use the Mohr circle to determine the principal strains. Use the constitutive relations to deduce the acting stresses. Similarly the students manipulate and solve equations related to fluid mechanics to explore the flow in pipes characteristics and pressure loss with special focus on the blood flow in arteries and veins.

g. an ability to apply written, oral, and graphical communication in both technical and nontechnical environments; and an ability to identify and use appropriate technical literature.

h. an understanding of the need for and an ability to engage in self-directed continuing professional development.

i. an understanding of and a commitment to address professional and ethical responsibilities including a respect for diversity.

j. a knowledge of the impact of engineering technology solutions in a societal and global context and an understanding of the clinical application of biomedical equipment.

k. a commitment to quality, timeliness, and continuous improvement.

Major Topics covered and schedule in weeks:

1. Free body diagram(FBD), application of FBD to human joints, stress state in point
2. Moh'r circle for stresses, Moh'r circle for special loading conditions
3. Elastic strains, strain gage principle, application to Rosette strain gage, Moh'r circle for strains, stress-strain relationships
4. Difference between solids, fluids and gas. Fluid Statics; incompressible fluids, Pascal's principle, pressure calculation using constant density formula, application to manometry
5. Fluid dynamics; non-viscous fluids; continuity, energy, and Bernouilli's equation.
6. Static consequences of Bernouilli's equation: blood pressure measurement by cannulation. Dynamic consequences of Bernouilli's equation: Flowmeters (Venturi tube, Prandtl tube and Pitot tube), Toricelli's equation.
7. Viscous fluids; Newtonian and non-Newtonian fluids, Newton's law of viscosity, absolute and kinematic viscosity, viscosity in liquids and gases.
8. Laminar vs turbulent flows and Reynolds number, Poiseuille's law, power dissipation,
9. Flow of blood in the circulatory system, flow resistance, major and minor head losses in ducts and pipes