MPY101 : Physics of Living Systems 2

Semester : 2 Credits : 10

Taught by: Dr A Narracott / Dr J Fenner

Prerequisites: None
Co-requisites: None

Brief Description (including aims of module)
The aim is to introduce biomechanics and biofluids descriptions of the human body. We look at its structure and its performance as a physical machine. The structural characteristics of human bones and tissue are investigated, together with the mechanical functions of the skeleton and musculature. Simple fluid dynamic characteristics of the body are introduced, including descriptions of blood-flow in the arteries and veins. The underlying mathematical descriptions used to describe structural and fluid dynamic effects in the body are discussed along with potential limitations of these approaches.

Objectives
At the end of the course the student will:

1. understand the types of loads that are applied to biomechanical structures and understand the principal engineering characteristics of a deformable material;
2. understand the basic structure of bone and tissue and have a feel for their respective strengths and stiffnesses;
3. understand the principles of static equilibrium, and be able to apply them to simple biomechanical analyses;
4. recognise the possibility of structural instabilities in thin or slender members, and be able to perform simple calculations to assess them;
5. recognise the design principles at work in the human skeleton;
6. be aware of the magnitudes of the loads within the skeleton and musculature during everyday tasks such as lifting;
7. understand design methodologies for prosthetic components, including the principles of stress and deflection analyses;
8. appreciate the engineering effects of physical scale in the animal kingdom;
9. be able to calculate hydrostatic pressure distributions, and their effect on parameters such as blood pressure;
10. recognise the fundamental fluid dynamic parameters of pressure and velocity, and the role of viscosity in fluid flow;
11. be able to identify flow regimes by Reynolds' number and pulsatility parameters, and recognise the flow regime in biofluid mechanical systems, particularly in the cardiovascular system;
12. understand the effects of orifices and constrictions, particularly with respect to the performance of components such as natural or prosthetic heart valves.

Outline Syllabus

- Strength of materials: elasticity and viscoelasticity, structure and strength of bone and tissue, modulus (Young's, bulk etc.).
- Equilibrium: forces, moments and couples, applications in biomechanics, energy methods.
- Stress analysis: tension and compression, Engineer's theory of bending, shear and torsion, structural instability of columns (Euler's method).
- Kinetics and kinematics: joint design.
- Hydrostatic pressure distribution: blood pressure.
- Properties of fluids in motion: viscosity, Newtonian models, blood models.
- Fluid dynamics: classification of flow regimes, Navier Stokes equation, Poiseuille equation, Bernoulli equation, Gorlin equation, models of cardiovascular system, haemolysis and thrombosis.
- Special considerations: introduction to methods for dealing with elastic walls of arteries, collapsible veins, Windkessel model, Moens Korteweg wave speed.

Mathematics used in the Module

- Differentiation/Integration of simple functions (polynomial, trigonometric, exponential)
- Solution of simple differential equations, first/second order linear

Module Format

Lectures	19
Tutorial Classes	5
Laboratory work	0
Private study	36

Main Text Books

'Medical Physics and Biomedical Engineering'
BH Brown, RH Smallwood, DC Barber, PV Lawford, DR Hose
IOP Publishing Ltd, 1999. ISBN 0 7503 0368 9 (Paperback)

Comprehensive printed notes are supplied, together with an extensive reading list.

Assessment

Two hour written examination	80 %
Coursework assignments	20 %