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MANGALORE INSTITUTE OF TECHNOLOGY & ENGINEERING

(A Unit of Rajalaxmi Education Trust®, Mangalore)
Autonomous Institute affiliated to VTU, Belagavi, Approved by AICTE, New Delhi
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Model Question Paper

Seventh Semester BE Degree Examination

Biomechatronics

Time: 3 Hours(180 Minutes) **Max. Marks: 100**

Note: 1. Answer any FIVE full questions, choosing ONE full question from each module.
2. M: Marks, L: RBT (Revised Bloom's Taxonomy) level, C: Course outcomes.

		Module -1	**M**	**L**	**C**
Q1	a.	Define mechatronics and biomechatronics. With a neat block diagram, distinguish between the two fields.	06	L2	CO1
	b.	Illustrate the various components of a Biomechatronics system.	06	L2	CO1
	c.	Describe the major physiological systems of the human body, and explain the relevance of any two to the design of biomechatronic devices.	08	L2	CO1
		OR			
Q2	a.	With a neat sketch, explain the working of a pulse oximeter and map its parts onto the six components of a biomechatronic system.	06	L2	CO1
	b.	Explain the fusion of biology and mechatronics with respect to manipulation, locomotion, sensory interaction, and processing, with suitable examples.	06	L2	CO1
	c.	Discuss the scope and applications of biomechatronics in modern healthcare, citing examples of devices associated with at least three different physiological systems.	08	L2	CO1
		Module- 2			
Q3	a.	Explain any two electromagnetic actuators.	04	L2	CO4
	b.	An actuator is to be chosen for a wearable rehabilitation exoskeleton that will remain in direct physical contact with a stroke patient's arm throughout therapy. Apply the design goals of safety, performance, and ease of use, and recommend a suitable actuator type.	08	L3	CO4
	c.	A patient with a transradial (below-elbow) amputation is being fitted with a prosthetic hand. Analyse the trade-offs between a body-powered actuation system and a motor-driven (powered) actuation system for this device, and justify which option better serves the purpose of biological function replacement for an active, cost-conscious user.	08	L3	CO4
		OR			
Q4	a.	Differentiate between linear and rotary transmission elements.	04	L2	CO4
	b.	An implantable device requires an actuator to precisely position a delicate electrode array, where compactness, biocompatibility, and smooth motion are critical but high actuation speed is not. Evaluate whether a Shape Memory Alloy (SMA) actuator or an Electroactive Polymer (EAP) actuator is better suited to this scenario, based on their respective operating principles.	08	L3	CO4
	c.	A motor-driven prosthetic hand is to be developed for a transradial amputee for everyday tasks such as gripping a cup, a door handle and a pen. Outline the steps you would follow to select a suitable electromagnetic actuator and its transmission for this hand. Show how the three design goals guide your choice.	08	L3	CO4

Module – 3					
Q5	a.	Classify sensory receptors used in biomechatronic sensing, and explain the neuromuscular anatomy relevant to the generation of biomedical signals.	06	L2	CO2
	b.	Explain the working principle of surface EMG and intramuscular EMG sensors, highlighting their respective advantages and limitations.	06	L2	CO2
	c.	With a neat sketch, explain the working principle of an oxygen sensor used for monitoring blood oxygen saturation, and discuss its significance in biomechatronic and clinical monitoring systems.	08	L2	CO2
OR					
Q6	a.	Describe the working principle and clinical significance of ECG, EEG, and EOG sensors used in biomechatronic systems.	06	L2	CO2
	b.	Explain what is meant by natural sensors in the human body, and describe the origin and characteristic amplitude and frequency ranges of the common biomedical signals used in biomechatronic systems.	06	L2	CO2
	c.	With a neat diagram, explain the monopolar and bipolar electrode configurations used for recording biopotential signals, and discuss the significance of nerve cuff electrodes.	08	L2	CO2
Module – 4					
Q7	a.	Explain the working principle of a Bone Anchored Hearing Aid (BAHA), describing the phenomenon of osseointegration and its advantage in cases of conductive hearing loss.	06	L2	CO3
	b.	Compare analog and digital hearing aid amplifiers with respect to signal processing capability, frequency response shaping, signal compression and power consumption.	06	L2	CO3
	c.	With a neat block diagram, explain the construction and operation of a hearing aid, describing the function of the microphone, amplifier, receiver and battery.	08	L2	CO3
OR					
Q8	a.	Explain the principle of operation of any one middle ear implant device highlighting its advantages over conventional hearing aids.	06	L2	CO3
	b.	Describe the working principle of sonar-based systems used as travel aids for the visually impaired, and explain the concept of sensory substitution.	06	L2	CO3
	c.	With a neat diagram, explain the anatomy of the visual pathway and the working principle of a visual neuroprosthesis used for restoring perception in the visually impaired.	08	L2	CO3
Module – 5					
Q9	a.	Explain the phases of the gait cycle, describing the events that occur during the stance and swing periods and their significance in the design of lower-limb prostheses.	04	L2	CO5
	b.	A prosthetic leg has a mass of 3 kg, with its centre of mass 220 mm from the knee joint and a radius of gyration of 150 mm about the centre of mass. Determine (i) the moment of inertia about the centre of mass, (ii) the moment of inertia about the knee joint using the parallel axis theorem, and (iii) the angular acceleration produced when a torque of 5 Nm is applied at the knee.	08	L3	CO5
	c.	A leg is modelled as three segments along the same axis — thigh (mass 4 kg, centre of mass 0.22 m from the hip), shank (mass 2.5 kg, centre of mass 0.55 m from the hip) and foot (mass 1 kg, centre of mass 0.78 m from the hip). Treating each segment as a point mass, determine (i) the position of the centre of mass of the complete limb from the hip, (ii) the moment of inertia of the limb about the hip joint, and (iii) the moment of inertia of the limb about its own centre of mass.	08	L3	CO5

		OR			
Q10	a.	Define centre of mass, moment of inertia and radius of gyration as applied to a limb segment, and state the parallel axis theorem as used in limb dynamics.	04	L2	CO5
	b.	During the mid-swing phase of the gait cycle, the knee flexes to 60° at an angular velocity of about 350°/s. Assuming this angular velocity is uniform, determine (i) the time taken to reach 60° flexion from full extension, (ii) the angular velocity expressed in rad/s, and (iii) the constant torque required to bring the shank–foot segment, of moment of inertia 0.12 kg·m² about the knee, to rest from this angular velocity in 0.05 s.	08	L3	CO5
	c.	An actively controlled knee prosthesis applies a damping torque of 8 Nm to the shank–foot segment, which has a moment of inertia of 0.12 kg·m² about the knee axis and is rotating at 6 rad/s. Determine (i) the resulting angular deceleration, (ii) the time taken to bring the segment to rest, and (iii) the angle through which the segment rotates during this period.	08	L3	CO5

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