

Program Name : Diploma in Instrumentation / Instrumentation and Control
Program Code : IS / IC
Semester : Sixth
Course Title : Biomedical Instrumentation
Course Code : 22648

1. RATIONALE

The use of biomedical instruments is increasing day by day in health care. Now- a- days advanced, complex and precision biomedical instruments are used in most of the hospitals. Instrumentation engineering diploma pass outs have to know about the biomedical instrumentation fundamentals to understand physiology of human body as well as construction, working, application of different biomedical instruments. Hence this course has been designed to develop some of the basic skills in operation, testing and maintenance of various biomedical instruments.

2. COMPETENCY

The aim of this course is to help the student to attain the following industry identified competency through various teaching learning experiences:

- **Maintain biomedical instrumentation systems.**

3. COURSE OUTCOMES (COs)

The theory, psychomotor and relevant soft skills associated with this course are to be taught and implemented, so that the student demonstrates the following industry oriented COs associated with the above mentioned competency:

- Identify the functions of anatomy and physiology of human body.
- Maintain the biomedical instruments /electrodes for relevant applications.
- Select the relevant biomedical instruments for biomedical parameters measurement.
- Maintain life support biomedical instruments for specified applications.
- Maintain biomedical imaging instrument for specified applications.

4. TEACHING AND EXAMINATION SCHEME

Teaching Scheme			Credit (L+T+P)	Examination Scheme												
L	T	P		Theory						Practical						
				Paper Hrs.	ESE		PA		Total		ESE		PA		Total	
					Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min
3	-	2	5	3	70	28	30*	00	100	40	25@	10	25	10	50	20

(*): Under the theory PA, Out of 30 marks, 10 marks are for micro-project assessment to facilitate integration of COs and the remaining 20 marks is the average of 2 tests to be taken during the semester for the assessment of the cognitive domain UOs required for the attainment of the COs.

Legends: L-Lecture; T – Tutorial/Teacher Guided Theory Practice; P - Practical; C – Credit, ESE - End Semester Examination; PA - Progressive Assessment

5. COURSE MAP (with sample COs, PrOs, UOs, ADOs and topics)

This course map illustrates an overview of the flow and linkages of the topics at various levels of outcomes (details in subsequent sections) to be attained by the student by the end of the



course, in all domains of learning in terms of the industry/employer identified competency depicted at the centre of this map.

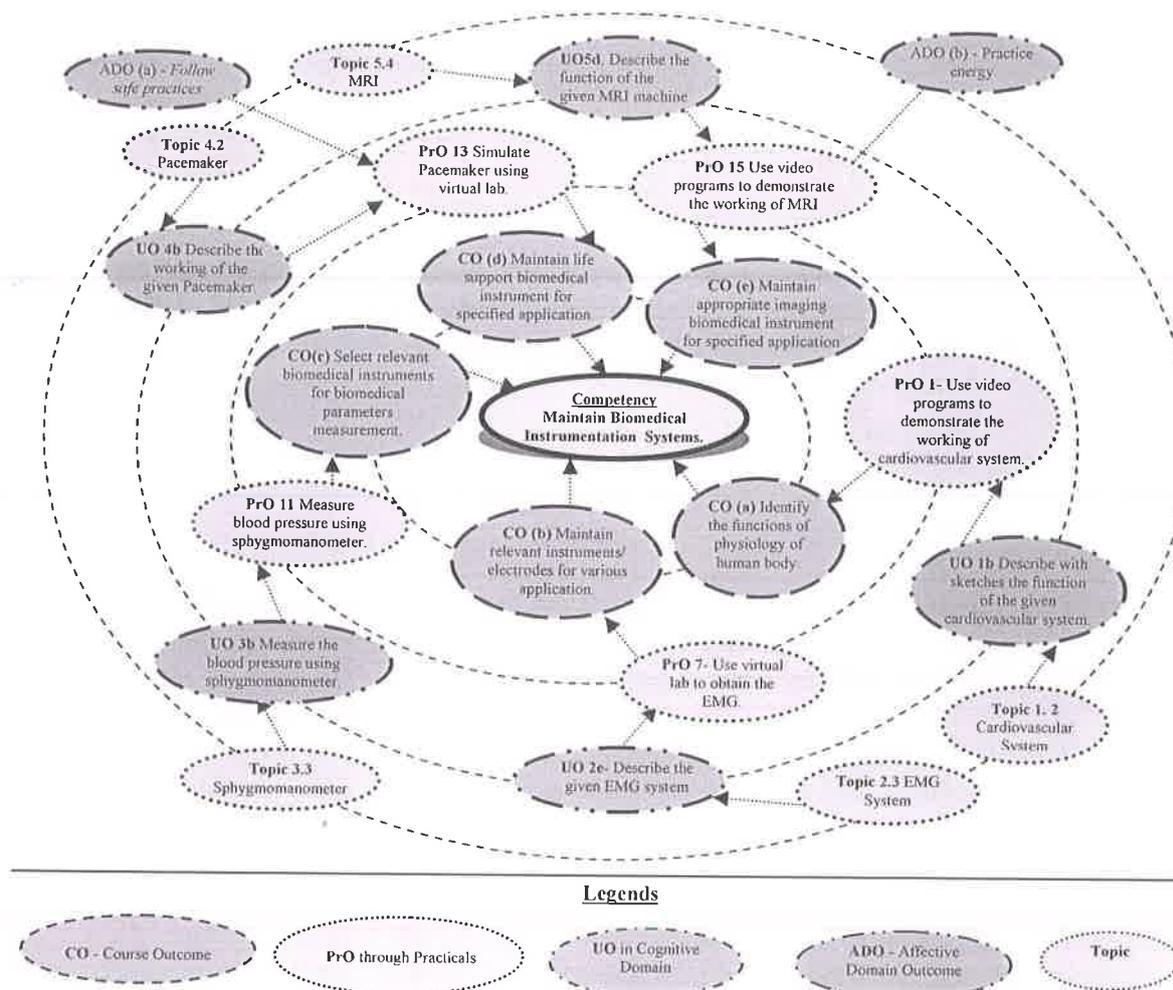


Figure 1 - Course Map

6. SUGGESTED PRACTICALS/ EXERCISES

The practicals in this section are PrOs (i.e. sub-components of the COs) to be developed and assessed in the student for the attainment of the competency.

S. No.	Practical Outcomes (PrOs)	Unit No.	Approx. Hrs. Required
1	Use video programs to identify the parts and working of cardiovascular system.	I	02*
2	Use video programs to identify the parts and working of Respiratory system.	I	02*
3	Use video programs to identify the parts and working of nervous system.	I	02*
4	Use video programs to identify the parts and working of excretory system.	I	02*
5	Use video programs to identify the parts and working of different electrodes.	II	02*
6	Use ECG machine safely to measure electrocardiogram.	II	02*
7	Use ECG machine to obtain the Electromyogram with the help of	II	02*

S. No.	Practical Outcomes (PrOs)	Unit No.	Approx. Hrs. Required
	virtual lab.		
8	Simulate 12 Lead electrocardiogram Signals using virtual lab.	II	02
9	Use phonocardiograph to obtain phonocardiogram.	III	02
10	Use Spirometer to measure respiration rate.	III	02
11	Use sphygmomanometer to measure blood pressure.	III	02*
12	Use Defibrillator machine to defibrillate the fibrillated heart with the help of virtual lab.	IV	02*
13	Use artificial Pacemaker to simulate heart with the help of virtual lab.	IV	02
14	Use Hemodialysis Machine to dialyze the kidney with the help of virtual lab.	IV	02*
15	Use video programs to identify the parts and the working of MRI machine	V	02*
16	Use video programs to identify the parts and working of X-RAY machine.	V	02*
17	Use video programs to identify the parts and the working of CAT machine.	V	02
	Total		34

Note

- i. A suggestive list of PrOs is given in the above table. More such PrOs can be added to attain the COs and competency. A judicious mix of minimum 12 or more practical need to be performed, out of which, the practicals marked as '*' are compulsory, so that the student reaches the 'Precision Level' of Dave's 'Psychomotor Domain Taxonomy' as generally required by the industry.
- ii. The 'Process' and 'Product' related skills associated with each PrO is to be assessed according to a suggested sample given below:

S. No.	Performance Indicators	Weightage in %
1	Preparation of experimental setup.	20
2	Setting and operation.	20
3	Safety measures.	10
4	Observation and recording.	10
5	Interpretation of result and conclusion.	20
6	Answer to sample questions.	10
7	Submission of report in time.	10
	Total	100

The above PrOs also comprise of the following social skills/attitudes which are Affective Domain Outcomes (ADOs) that are best developed through the laboratory/field based experiences:

- a) Follow safety practices.
- b) Practice good housekeeping.
- c) Practice energy conservation.
- d) Work as a leader/a team member.
- e) Follow ethical Practices.



The ADOs are not specific to any one PrO, but are embedded in many PrOs. Hence, the acquisition of the ADOs takes place gradually in the student when s/he undertakes a series of practical experiences over a period of time. Moreover, the level of achievement of the ADOs according to Krathwohl's 'Affective Domain Taxonomy' should gradually increase as planned below:

- 'Valuing Level' in 1st year
- 'Organisation Level' in 2nd year
- 'Characterisation Level' in 3rd year

7. MAJOR EQUIPMENT/ INSTRUMENTS REQUIRED

The major equipment with broad specification mentioned here will usher in uniformity in conduct of experiments, as well as aid to procure equipment by authorities concerned.

S. No.	Equipment Name with Broad Specifications	PrO. S. No.
1	Computer system; Operating System: Windows 10 or higher Memory: minimum of 1 GB RAM, Processor Speed: minimum of Intel Core i5 or equivalent, Hard Drive: 320 GB or larger Internet connection and projector	1 to 17 except 6,9,10,11
2	ECG machine-10 or 12 lead with sensitivity 5, 10, 20, auto (I~aVF: 10, V1~V6: 5) mm/mV	6
3	Phono cardiograph - Contact type MIR sensor Phono-pre-amplifier: Matched to sensor with gain adjustable up to 5000. Frequency response: 10 Hz to 2 KHz (+ 1db) Filter: Mass-Weber type with cut-offs at 1 KHz with slopes of 20 db, 30db, 40db and 60db per octave. Adjustable by 5-Way rotary switch. Output Level: Audio-visual indication with light flashes and beeps. Output electrical signal available: 2 Volts peak to peak. Output impedance: Less than 100 ohms.	9
4	Digital Storage Oscilloscope ; 60MHz/100MHz/200MHz bandwidth, 500MS/s to 1GS/s real-time sample rate, 50GS/s sample rate for repetitive waveforms, High resolution color LCD display	
5	Spirometer: Volume: 12 L Range: 0 to +/- 15 L/sec Accuracy: Better than 2% of scale Resistance: @ 10 L/sec < 5 mmH ₂ O Digital resolution: Optical encoder 8ml Temperature: Internal spirometer thermistor	10
6	Sphygmomanometer: Bulb - pumps air into the cuff, larger sizes available. Valve - twists clockwise to deflate the cuff. Gauge - watch-like hand, measures in mmHg. Cuff - restricts blood flow, has inflatable bladder, has Velcro. Working Cycle	10-13,17

8. UNDERPINNING THEORY COMPONENTS

The following topics are to be taught and assessed in order to develop the sample UOs given below for achieving the COs to attain the identified competency. More UOs could be added.

Unit	Unit Outcomes (UOs) (in cognitive domain)	Topics and Sub-topics
Unit – I Fundamentals of Physiology	1a. Describe the function of the given components of Man - instrument system with sketch. 1b. Describe with sketches the	1.1 Man-Instrument System: Block diagram, Elements. 1.2 Cardiovascular System: Structure of heart, cardiovascular circulation, electrical conduction system of heart, generation of



Unit	Unit Outcomes (UOs) (in cognitive domain)	Topics and Sub-topics
	function of the given human physiology system. 1c. Explain the given parameters related to Cardiovascular system 1d. Describe the function of the given part of human Nervous system.	heart sound, importance of cardiac output. 1.3 Respiratory system: Physiology of respiratory system, mechanism of breathing, lung volumes and capacities. 1.4 Nervous system: Structure and functioning of neuron. Structure of brain. Functions of cerebrum, cerebellum, pons, mid brain, medulla oblongata, thalamus, hypothalamus, Spinal cord. Neuronal Communication diagram and description. 1.5 Kidney: Nephron, Structure, functions and operation.
Unit– II Bioelectric Signals and Electrode System	2a. Describe with sketches the use of the given bioelectric potentials of human body. 2b. Select the relevant bioelectric electrodes to measure the given situation with justification. 2c. Explain with sketches the working of the given bioelectric instrument to measure bioelectric potentials of human body. 2d. Select relevant ECG lead system to for the given situation with justification. 2e. Interpret the specification of the given instrument/ electrode. 2f. Describe the procedure to maintain the given bioelectric instrument used to measure bioelectric Signals	2.1 Bio-Electric Potential: Resting and Action potentials- Concept, schematic diagrams, waveform. Electrode Theory- Electrode electrolyte interface with schematic diagram 2.2 Bio-Electrode: Construction and diagram of various electrodes used for measuring ECG, EEG and EMG. a) Microelectrodes b) Surface electrodes: Suction cup electrode, Disposable electrode, Floating type electrode, Metal Disk electrode c) Needle electrodes. 2.3 ECG system: Block diagram, Working. Leads – Unipolar, Bipolar-Einthoven triangle. Electrocardiogram- Waveform, Interpretation. 2.4 EMG system: Electromyography- Concept, Block diagram and working. 2.5 EEG: Electroencephalogram, block diagram, working, waveforms and description of various stages of sleep
Unit– III Biomedical Parameters Measurement	3a. Describe with sketches the origin of given heart sound. 3b. Describe with sketches the construction of the given biomedical instrument for measuring the given parameter. 3c. Explain with sketches the working of the given biomedical instrument for measuring the given parameter. 3d. Interpret the specification of the given biomedical instrument. 3e. Describe the procedure to	3.1 Measurement of heart sound: Phonocardiograph- Block diagram, working. 3.2 Blood Pressure measurement: Principle, list the types of direct and indirect method of blood pressure measurement. Sphygmomanometer: Construction, working of sphygmomanometer. Blood pressure measurement using sphygmomanometer. 3.3 Blood flow Measurement: Diagram, construction and working - Plethysmograph, electromagnetic, ultrasonic method. 3.4 Respiration rate Measurement: Diagram, construction and working of Spirometer 3.5 Audiometer: Construction, working and applications.



Unit	Unit Outcomes (UOs) (in cognitive domain)	Topics and Sub-topics
	maintain the given biomedical instrument used to measure the given parameters.	
Unit-IV Life Support Instruments and Electrical Safety	4a. Describe with sketches the construction of the given life support instrument. 4b. Explain with sketches the working of the given Life support instrument. 4c. Interpret the specifications of the given Life support instrument. 4d. State patient safety precautions to be taken for given electric shock and leakage current. 4e. Describe the procedure to maintain the given life support instrument.	4.1 Defibrillator: Concept of fibrillation, defibrillation. Types of defibrillators. DC defibrillation-diagram, working, output waveforms. Electrodes used - Paddle electrodes. 4.2 Pacemaker: Concept of Pacemaker. Types of Pacemaker - internal and external. Working of various pacing modes. Block diagram of Pacemaker and its working. 4.3 Hemodialysis machine: Need, function, block diagram, working, 4.4 Biotelemetry: Block diagram, working. 4.5 Micro shock and macro shock: Effects of leakage current on human body. Types of leakage current. Precaution to minimize electric shock hazards and leakage current
Unit –V Imaging Systems	5a. Describe with sketches the construction of the given imaging system 5b. Explain with sketches the working of the given imaging systems. 5c. Describe the given modes of Ultrasonography. 5d. Interpret the specifications of the given imaging system. 5e. Describe the procedure to maintain the given instrument used to measure imaging systems.	5.1 X-ray: Principle of X rays. X ray machine-Block diagram, working, Application, specifications. Image intensifier- schematic diagram and working. 5.2 CAT: Principle of CT scan, Block diagram, working, Applications, specifications. 5.3 Ultrasonography: Principle, Block diagram, working, applications, specification. Various modes of ultrasonography- A, B and M mode. 5.4 MRI: construction, working, application, specification. 5.5 Tomography (PET): Single Photon Emission Computer Tomography (SPECT) - construction, working, application, specification.

Note: To attain the COs and competency, above listed UOs need to be undertaken to achieve the 'Application Level' and above of Bloom's 'Cognitive Domain Taxonomy'

9. SUGGESTED SPECIFICATION TABLE FOR QUESTION PAPER DESIGN

Unit No.	Unit Title	Teaching Hours	Distribution of Theory Marks			
			R Level	U Level	A Level	Total Marks
I	Fundamentals of Physiology	10	06	12	--	18
II	Bioelectric Signals and Electrodes system	10	04	10	--	14
III	Biomedical Parameters Measurement	10	04	06	02	12
IV	Life Support Instruments and	10	04	06	04	14



Unit No.	Unit Title	Teaching Hours	Distribution of Theory Marks			
			R Level	U Level	A Level	Total Marks
	Electrical Safety					
V	Imaging Systems	08	02	04	06	12
	Total	48	20	38	12	70

Legends: R=Remember, U=Understand, A=Apply and above (Bloom's Revised taxonomy)

Note: This specification table provides general guidelines to assist student for their learning and to teachers to teach and assess students with respect to attainment of UOs. The actual distribution of marks at different taxonomy levels (of R, U and A) in the question paper may vary from above table.

10. SUGGESTED STUDENT ACTIVITIES

Other than the classroom and laboratory learning, following are the suggested student-related *co-curricular* activities which can be undertaken to accelerate the attainment of the various outcomes in this course: Students should conduct following activities in group and prepare reports of about 5 pages for each activity, also collect/record physical evidences for their (student's) portfolio which will be useful for their placement interviews:

- Prepare power point presentation or animation for understanding the working of physiology of human body organs.
- Visit to hospital to understand the operation of various imaging equipments.
- Visit to hospital to understand the operation of various life support equipments.
- Read the safety precautions of various biomedical equipments.
- Library /Internet survey of advanced biomedical equipment.
- Prepare power point presentation or animation for understanding the concept of working of biomedical instrument.
- Prepare a survey report on biotelemetry.

11. SUGGESTED SPECIAL INSTRUCTIONAL STRATEGIES (if any)

These are sample strategies, which the teacher can use to accelerate the attainment of the various learning outcomes in this course:

- Massive open online courses (*MOOCs*) may be used to teach various topics/sub topics.
- 'L' in item No. 4 does not mean only the traditional lecture method, but different types of teaching methods and media that are to be employed to develop the outcomes.
- About *15-20% of the topics/sub-topics* which is relatively simpler or descriptive in nature is to be given to the students for *self-directed learning* and assess the development of the COs through classroom presentations (see implementation guideline for details).
- With respect to item No.10, teachers need to ensure to create opportunities and provisions for *co-curricular activities*.
- Video programs/YouTube may be used to teach various topics and sub topics.
- Demonstrate students thoroughly before they start doing the practice.
- Encourage students to refer different book and websites to have deeper understanding of the subject.
- Observe continuously and monitor the performance of students in Lab.
- Encourage students to use front/rear panel control of electronic instruments.
- Encourage students to visit nearby electronic instruments repair workshop units or manufacturing industries.
- Instruct students to safety concern of handling electronic instruments and also to avoid any damage to the electronic instruments.



12. SUGGESTED MICRO-PROJECTS

Only one micro-project is planned to be undertaken by a student that needs to be assigned to him/her in the beginning of the semester. In the first four semesters, the micro-projects are group-based. However, in the fifth and sixth semesters, it should be preferably be **individually** undertaken to build up the skill and confidence in every student to become problem solver so that s/he contributes to the projects of the industry. In special situations where groups have to be formed for micro-projects, the number of students in the group should **not exceed three**.

The micro-project could be industry application based, internet-based, workshop-based, laboratory-based or field-based. Each micro-project should encompass two or more COs which are in fact, an integration of PrOs, UOs and ADOs. Each student will have to maintain dated work diary consisting of individual contribution in the project work and give a seminar presentation of it before submission. The total duration of the micro-project should not be less than **16 (sixteen) student engagement hours** during the course. The student ought to submit micro-project by the end of the semester to develop the industry oriented COs.

Suggestive lists of micro-projects are given here. Similar micro-projects could be added by the concerned faculty:

- Prepare report on abnormalities found in ECG/EEG/EMG waveforms by collecting different samples.
- Prepare a survey report on Blood pressure measurement of different age group and prepare comparative chart.
- Visit a hospital and prepare a survey report on different instrument used in ICU.
- Visit a hospital and prepare a detail report on electrical safety of different biomedical instrument.
- Prepare comparative specification chart of different models of life support equipments.
- Prepare comparative specification chart of different models of equipments to measure bioelectric potential using ECG/EEG/EMG.

13. SUGGESTED LEARNING RESOURCES

S. No.	Title of Book	Author	Publication
1	Handbook of biomedical instrumentation	Khandpur; R. S.	McGraw Hill New Delhi 2014 ISBN: 9789339205430
2	Introduction to biomedical equipment technology	Carr, Joseph J, Brown, J.M	Pearson education, New Delhi 2002 ISBN: 9788177588835
3	Biomedical instrumentation measurements.	Cromwell, Lesli P, Weibell, Fred J., Pfeiffer, Erich A.	PHI Learning, New Delhi 2 nd edition 2002, ISBN:, 9780130764485
4	Medical instrumentation application and design	Webster, John G.	John Wiley and Sons, New Delhi 2009, ISBN:978-0-471-67600-3

14. SUGGESTED SOFTWARE/LEARNING WEBSITES

- <http://bmsp-coep.vlabs.ac.in/PulseMissingDetector/index.html>
- <http://bmsp-coep.vlabs.ac.in/#>
- https://www.youtube.com/watch?v=_lgd03h3te8
- <https://www.youtube.com/watch?v=CkGqp5tr-Qk>
- https://www.youtube.com/watch?v=hc1YtXc_84A
- <https://www.youtube.com/watch?v=44B0ms3XPKU>
- <https://www.youtube.com/watch?v=HnKMB11ih2o>
- <https://www.youtube.com/watch?v=xIZQRjkwV9Q>
- <https://www.youtube.com/watch?v=XMizSSOejg0>



- j) <https://www.youtube.com/watch?v=m6SC7hOnAEI>
- k) <https://www.youtube.com/watch?v=Ok9ILlYzmaY>
- l) <https://www.youtube.com/watch?v=e19nlN6JRH4>
- m) <https://www.youtube.com/watch?v=bn4m1VO2OzQ>
- n) <https://www.youtube.com/watch?v=QD1PaKSBUmw>
- o) <https://www.youtube.com/watch?v=S2EEixdkL8A>



