Program Name : **Diploma in Medical Electronics**

Program Code : **MU**

Semester : **Fourth**

Course Title : **Analytical Equipment**

Course Code : **22435**

1. RATIONALE

A medical electronics engineer must be familiar with modern analytical equipment for the purpose of diagnosis of various physiological abnormalities. This course is useful in understanding the design concept, working principle, application oriented operating procedure, installation and maintenance of almost all analytical equipment used in hospital and pathology laboratory. Through this course the students will develop skills to handle modern analytical equipment in the pathology lab, different food industries, fabric industries, and agriculture area as well as research laboratories.

2. COMPETENCY

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

- **Operate various analytical equipment.**

3. COURSE OUTCOMES (COs)

The theory, practical experiences 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:

a. Use basic analytical equipment.
b. Operate different types of centrifuges and sterilizing equipment.
c. Measure different types of components of blood using analytical instruments.
d. Quantify pH and conductivity of body fluid.
e. Measure the different pollutants present in the environment.

4. TEACHING AND EXAMINATION SCHEME

Teaching Scheme			Credit (L+T+P)	Examination Scheme												
				Theory							Practical					
L	T	P		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.

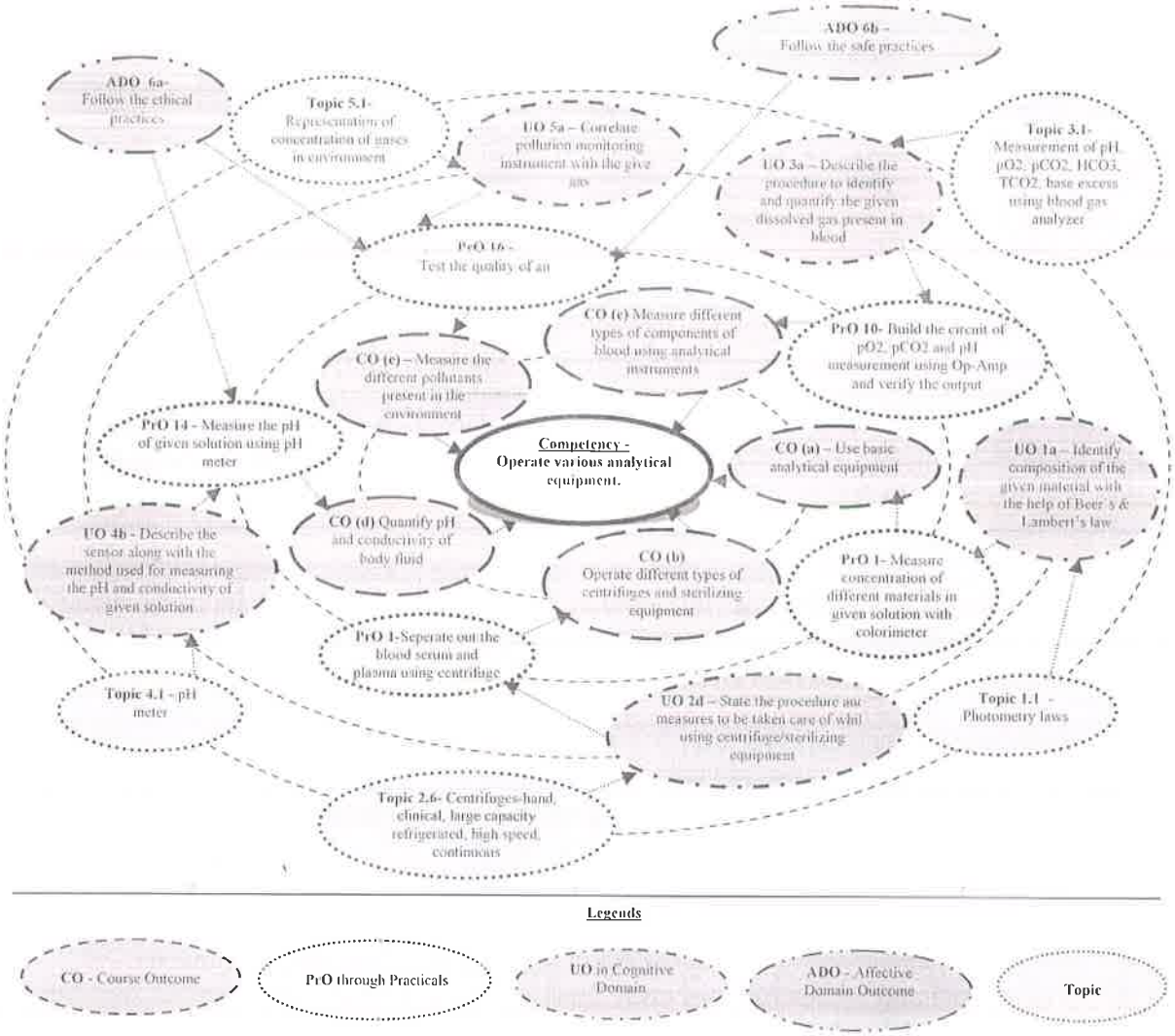

Figure 1 - Course Map

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.	Measure concentration of different materials in given solution with the help of colorimeter.	I	02*
2.	Measure concentration of different materials in given solution with the help of spectrophotometer.	I	02
3.	Use flame photo meter to calculate the concentration of sodium potassium, iodine calcium.	I	02
4.	Use centrifuge to separate out the blood serum and plasma.	II	02*
5.	Use ultrasonic cleaner to sterilize micro components.	II	02
6.	Use hot air oven to sterilize hospital utensils.	II	02
7.	Use autoclave to sterilize biomedical waste.	II	02
8.	Use incinerator machine dispose biomedical wastes.	II	02

S. No.	Practical Outcomes (PrOs)	Unit No.	Approx. Hrs. Required
9.	Use electrophoresis apparatus to separate out the bio particles.	III	02*
10.	Use Op-Amp to build the circuit for pO2, pCO2 and pH measurement.	III	02
11.	Use auto-analyzer to find out the concentration of different components of blood.	IV	02*
12.	Use Blood cell counter to measure WBC, RBC, platelets in the blood.	IV	02
13.	Interpret the contents of the given sample using SEM and TEM.	IV	02
14.	Use pH meter m to measure the pH of given solution.	IV	02
15.	Use conductivity meter to xamine the conductivity of the given solution.	IV	02
16.	Use air quality detector to test the quality of air.	V	02*
	Total		**32**

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 judicial 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 set up	20
2	Setting and operation	10
3	Safety measures	10
4	Observations and recording	20
5	Interpretation of result and conclusion	20
6	Repairing and maintenance	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 safe practices.
b. Practice good housekeeping.
c. Practice energy conservation.
d. Demonstrate working as a leader/a team member.
e. Maintain tools and equipment.
f. 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
- 'Organising Level' in 2nd year

- 'Characterising 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. No.
1	Colorimeter : Automatic cooling,6-7 tests per hour, fixed bomb cylinder with removable head for fast sample loading, operator time per test is 1 minute,0.1% precision class instrument.0.0001 °c temperature resolution.5000 – 8000 calorie sample range,0.05% linearity across operating range.	I
2	Spectrophotometer: wavelength 190 to1100 nm,baseline stability less than 0.0003 Abs/H at 700 nm (one hour after light source turned ON), Baseline flatness: within ±0.0006 Abs (190 to 1100nm,one hour after light source turned ON), Noise level: Within 0.00005 Abs RMS value (at 700 nm)	II
3	Flame photometer: Filters: Na and K (Ca and Li optional), Range: Na: 0-100 ppm, Ca: 20-100 ppm, K : 0-100 ppm, Li: 10-100 ppm, Sensitivity: Na: 5 ppm, Ca: 10 ppm, K : 5 ppm, Li: 10 ppm	III
4	Ultrasonic Cleaner: Capacity:1.3 to 14 Liter Tank, Ultrasonic Cleaning Power:60W to 750W, Ultrasonic frequencies: 20KHz / 40KHz, Digital timer adjustment: 1-99 minutes, Digital temperature adjustment: 0-70 ^{0}C, Stainless Steel Basket and cover lid, Tank and housing made from Stainless Steel.	V
5	Centrifuge : max capacity: 3.0 L, Refrigerated and constant controlled models, 10,200 RPM, 11,400 x *g* ,ARIES Smart Balance Rotor System	IV
6	Hot air oven: Temperature Range: 5°C above ambient to 250°C maximum, Temperature Accuracy: + / - 2°C, Temperature Uniformity: + / - 1°C, Controls: PID Controller, Sensor: PT-100 Kanthal A1, Heating Element: Nichrome wire	VI
7	Autoclave : Electrical Power:18 KW or Sufficient wattage of industrial immersion type water heater to generate steam within a reasonable period of time on 3 phase 440V 50 HZ AC supply, Working pressure and Temperature : 1.2 to 2.2 Kg/sq.cm at 121 Deg C, Material of Construction Inner chamber , Jacket, Door : SS 316.(5mm-10mm), Outer Chamber : SS 304 (Insulated properly), Steam Generator : Non corrosive SS / Chromium plated Brass, Heater Plate : Brass / Stainless Steel	VII
8	Auto analyzer: Auto sampler, peristaltic pump, nitrate manifold designed for auto analyzer used, single channel colorimeter equipped with 15 mm flow cell and 550 nm filter /rp18 5 µm, 250 mm x 4 mm chromatographic hplc column, sampler- random access sampler with throughput of more than 150 samples in cups or tubes, manifold- should include applications for hydrogen cyanide measurements, flow cell- should be having bubble through the flow cell operation, colorimeter should be suitable for hydrogen cyanide analysis.	XI
9	Blood cell counter: 18 parameters with 3-part differential,1000 samples storage with histogram, touch screen operation, built-in self-monitoring system, low cost per test.	XII
10	Blood gas analyzer: Essential Measured parameters: pH, pCO2, pO2, Hb, Barometric Pressure Na+, K+, Ca++, Cl$^-$. All these parameters should be measured simultaneously , Calculated parameters should include BE, BE ecf, HCO_3, Lactate, Anion Gap, SaO_2 etc, Sample volume: less than 100ul, Fast analysis time: less than 60 sec	X

S. No.	Equipment Name with Broad Specifications	PrO. No.
11	Air quality detector: Power: Rechargeable NiMH battery pack: 18 - 24 hours of continuous operation time *(dependent upon the sensor array installed)* c/w plug-in battery charger / wall adapter (12 VDC or 100 - 240 VAC), Sample : Internal, automatic sample pump for "active" sampling of target environment, Operating Ranges: Temperature: 5°C to 50°C (41°F to 122°F); Relative Humidity: 0 - 99% RH non-condensing, Sensors: Carbon Monoxide (CO), Carbon Dioxide (CO_2), Sulphur Dioxide (SO_2), Ozone (O_3), Oxygen (O_2)	XVI

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 Laboratory Equipment	1a. Identify composition of the given material with the help of Beer's and Lambert's law with justification. 1b. Describe with sketches the function of the specified element of a generalized analytical instrument with a sketch. 1c. Describe the steps for calibration of the given analytical equipment. 1d. Describe with sketches the functions of the given parts of the specified analytical equipment. 1e. Identify the analytical equipment for the given application with justification. 1f. Explain with sketches the operating principle of the given analytical instrument along with its technical specifications.	1.1 Photometry laws (Beer's and Lambert's Law), deviation from Beer's law, quantitative analysis and choice of wavelength 1.2 Elements of analytical instruments 1.3 Colorimeter 1.4 Spectrophotometer – Single and dual beam 1.5 Flame photometer 1.6 Auto analyzer
Unit-II Centrifuges and Sterilizing Equipment	2a. Describe with sketches the construction of the given instrument. 2b. Explain with sketches the operating principle of the given analytical instrument along with its technical specifications. 2c. Identify the application of the specified centrifuge/ sterilizing equipment along with its importance and justification. 2d. Describe the procedure and measures to be taken care of when using the specified equipment.	2.1 Incinerator (Medical) 2.2 Ultracentrifuges-Preparative, Analytical 2.3 Hot air oven 2.4 Autoclave (Horizontal and vertical) 2.5 Sterilizer (Clinical) 2.6 Centrifuges-Hand, clinical, Large Capacity Refrigerated, High Speed, Continuous. 2.7 Ultrasonic cleaner 2.8 Freezer -40°/-80°C
Unit– III Blood Gas Analyzer, Blood Cell	3a. Describe the procedure to identify and quantify the given dissolved gas present in blood. 3b. Describe the procedure to measure the	3.1 Measurement of pH, pO_2, pCO_2, HCO_3, TCO_2, base excess using blood gas analyzer 3.2 Electro- Conductive blood cell

Unit	Unit Outcomes (UOs) (in cognitive domain)	Topics and Sub-topics
Counter and Electron Microscope	amount of specified blood cell. 3c. Describe with sketches the construction of the given equipment used to measure dissolved gases and cells present in blood. 3d. Describe with sketches the procedure of separation technique used for the specified application. 3e. Describe with sketches the construction of the given chromatography/ electrophoresis equipment. 3f. Identify in the given figure the parts of electron microscope with its function.	counter, Dark field blood cell counter 3.3 Definition, principle of Chromatography and electrophoresis 3.4 Classification of Chromatography: Gas and Liquid Chromatography 3.5 Capillary electrophoresis 3.6 Polyacrylamide gel electrophoresis (PAGE) 3.7 TEM (Transmission Electron Microscope) 3.8 SEM (Scanning Electron Microscope)
Unit– IV pH and Conductivity meter	4a. Describe with sketches the construction of equipment used to measure pH of the given solution. 4b. Describe with sketches of the specified sensor along with the method used for measuring the pH and conductivity of given solution. 4c. Interpret high frequency circuit of the given conductivity cell. 4d. Recommend the relevant method to improve the accuracy of the given type of conductivity meter with justification.	4.1 pH meter, Null method and direct method for conductivity measurement 4.2 2-electrode conductivity sensor, 4-electrode conductivity sensor, Inductive conductivity sensor 4.3 Beat frequency method 4.4 Equivalent circuit diagram of conductivity cell 4.5 Temperature compensation of conductivity measurement
Unit– V Environmental Pollution Monitoring Equipment	5a. Correlate pollution monitoring instrument with the given gas. 5b. Provide specifications of pollution monitoring station with respect to the given parameter. 5c. Explain with sketches the principle of operation of given type of air analyzer for analysis of the specified contents.	5.1 Representation of concentration of gases in environment 5.2 Instrument techniques and measurement range 5.3 Carbon monoxide 5.4 Hydrocarbons 5.5 Sulpher dioxide 5.6 Nitrogen dioxide 5.7 Ozone 5.8 Pollution monitoring station 5.9 Automated wet-chemical air analysis

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

9. SUGGESTED SPECIFICATION TABLE FOR QUESTION PAPER DESIGN

Unit	Unit Title	Teaching	Distribution of Theory Marks

No.		Hours	R Level	U Level	A Level	Total Marks
I	Laboratory Equipment	10	04	04	06	14
II	Centrifuges and Sterilizing Equipment	10	02	06	06	14
III	Blood Gas Analyzer, Blood Cell Counter and Electron Microscope	10	04	04	06	14
IV	pH and Conductivity meter	12	04	06	08	18
V	Environmental Pollution Monitoring Equipment	06	02	04	04	10
Total		**48**	**16**	**24**	**30**	**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:

a. Survey and present a report on details of various analytical equipment from Library / Internet.
b. Prepare power point presentation or animation for understanding operation and demonstration of analytical equipment.

11. SUGGESTED SPECIAL INSTRUCTIONAL STRATEGIES (if any)

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

a. Massive open online courses (***MOOCs***) may be used to teach various topics/sub topics.
b. ***'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.
c. 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).
d. With respect to item No.10, teachers need to ensure to create opportunities and provisions for ***co-curricular activities***.
e. Use Flash/Animations to explain various theorems in circuit analysis
f. Guide student(s) in undertaking micro-projects

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-project 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.

A suggestive list of micro-projects are given here. Similar micro-projects could be added by the concerned faculty:

a. Find out specifications of analytical instruments from various manufacturers. Prepare comparative statement of different analytical instrument with their specifications. Make a report.
b. Prepare model of colorimeter/spectrophotometer/flame meter using electronic components.
c. Build circuit for measurement of pCO2/ pO2 /pH using op amp circuits. Make a report.
d. Observe the performance of different analytical instruments and prepare calibration and testing report of the same.

13. SUGGESTED LEARNING RESOURCES

S. No.	Title of Book	Author	Publication
1	Handbook of Analytical Instruments	Khandpur, R. S.	McGraw-Hill Education, New Delhi, 2014, ISBN: 9339221362
2	Bioinstrumentation	Veerakumari, L.	MIR Publishers, Moscow, 2015 ISBN:9788180940187
3	Analytical Instrumentation: A Guide to Laboratory, Portable and Miniaturized Instruments	McMahon, Gillian	John Wiley & Sons, New Delhi, 2014, ISBN : 9780470027950
4	Principles of Instrumental Analysis	Skoog, Douglas A.; Holler, James F.; Stanley, R. Crouch	Cengage Learning, New Delhi, , 2017, ISBN: 9781337468039
5	Medical Instrumentation: Application and Design	Webster, John G.	John Wiley and Sons, New Delhi, 2009, ISBN: 9788126511068
6	Ewing's Analytical Instrumentation Handbook	Cazes, Jack	CRC Press, 2005 ISBN : 9780824753481

14. SUGGESTED SOFTWARE/LEARNING WEBSITES

a. http://www.parrinst.com/products/oxygen-bomb-calorimeters/6400-automatic-isoperibol-calorimeter/specifications
b. http://www.shimadzu.com/an/molecular_spectro/uv/uv1800/uv3.html
c. www.labtronicsspectrophotometers.com/digital-flame-photometers.html
d. http://smedunia.co.in/highcleanultrasonic
e. http://centrifugebybeckman.com/?page_id=1777/?pi_ad_id=92693587516andgclid=CPr7i8nlltICFUgXaAodFhkMQg
f. http://www.bionicsscientific.com/laboratory-oven/hot-air-oven.html
g. http://www.k2bw.com/gasanalyzers.htm
h. http://www.kmscl.kerala.gov.in/ratecontractspec/Autoclave%20horizontal.pdf

i. http://www.mohfw.nic.in/WriteReadData/l892s/file9-94625409.pdf
j. http://www.agdbio.com/product/pce-210-fully-automatic-blood-cell-counter
k. http://bmsicl.gov.in/uploads/Drugs/Blood%20Gas%20Analyser%20With%20Electrolyte.pdf
l. http://www.nptel.ac.in/courses/104104066/
m. http://www.eeprocess.com/CET/yesair-junior.html