Semester I

Discipline: MECHANICAL ENGINEERING

Stream: ME2

CODE	COMPUTATIONAL METHODS FOR ENGINEERS	CATEGORY	L	T	P	CREDIT
221TME100		Discipline Core	3	0	0	3

Preamble:

Numerical simulations are the most reliable tool of mechanical engineers to solve the problems in the domain and advanced computational methods are a critical component of that. This course targets to introduce the advanced numerical techniques required to solve the mechanical engineering problems.

Course Outcomes:

After the completion of the course the student will be able to

CO 1	Solve system of equations using numerical techniques
CO 2	Apply numerical schemes to integrate, differentiate and curve fit
CO 3	Determine solutions of ODE and PDE using computational methods
CO 4	Formulate a Mechanical Engineering problem and solve that using computer based numerical procedure and submit micro-project
CO 5	Apply two different numerical methods to solve (manual/computer) a problem and compare the merits and demerits of those schemes

	PO 1	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**
CO 1			3	2	3	2
CO 2			3	2	3	2
CO 3			3	2	3	2
CO 4	3	2		2	3	2
CO 5	2	2		2	3	2

Assessment Pattern

Bloom's Category	**End Semester Examination**
Apply	20%
Analyse	60%
Evaluate	20%
Create	

Mark distribution

Total Marks	CIE	ESE	ESE Duration
100	40	60	2.5 hours

Continuous Internal Evaluation: 40 Marks

Micro project/Course based project : 20 marks

(Formulate a mechanical engineering problem and solve that using computer based numerical procedure and submit as project. The project shall be done individually. Group projects not permitted.)
Course based task (programming)/Seminar/Quiz: 10 marks Test

paper, 1 No. : 10 marks

Test paper shall include minimum 80% of the syllabus.

End Semester Examination: 60 Marks

The end semester examination will be conducted by the University for Core Courses. There will be two parts; Part A and Part B. Part A will contain 5 numerical/short answer questions with 1 question from each module, having 5 marks for each question (such questions shall be useful in the testing of knowledge, skills, comprehension, application, analysis, synthesis, evaluation and understanding of the students). Students should answer all questions. Part B will contain 7 questions (such questions shall be useful in the testing of overall achievement and maturity of the students in a course, through long answer questions relating to theoretical/practical knowledge, derivations, problem solving and quantitative evaluation), with minimum one question from each module of which student should answer any five. Each question can carry 7 marks.

Model Question paper

QP Code: **Total Pages:**

Reg No.:_________ **Name:____________________**

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY
FIRST SEMESTER M.TECH DEGREE EXAMINATION, Month & Year
Discipline: Mechanical Engineering
Course Code: 221TME100
Course Name: Computational Methods for Engineers

Max. Marks: 60 **Duration: 2.5 Hours**

PART A

Answer all questions, each carries 5 marks. **Marks**

1	Use Gauss elimination to solve $3x_1 - 0.1x_2 - 0.2x_3 = 7.85$ $0.1x_1 + 7x_2 - 0.3x_3 = -19.3$ $0.3x_1 - 0.2x_2 + 10x_3 = 71.4$	**(5)**
2	Explain the procedure of Newton-Raphson method and draw a flowchart.	**(5)**
3	Explain the Trapezoidal rule and derive the equation for the same.	**(5)**
4	Use the classical fourth-order RK method to integrate $f(x, y) = -2x^3 + 12x^2 - 20x + 8.5$ using a step size of $h = 0.5$ and an initial condition of $y = 1$ at $x = 0$.	**(5)**
5	Write a short note on any simple implicit method.	**(5)**

PART B

Answer any 5 full questions, each question carries 7 marks.

6	Use Newton- Raphson method to determine a root of the equation $f(x) = x^3-13x-12$	**(7)**

7 Given these data, **(7)**

x	1.6	2	2.5	3.2	4	4.5
f(x)	2	8	14	15	8	2

Calculate f(2.8) using Newton's interpolating polynomials of order 1 through 3. Choose the sequence of the points for your estimates to attain the best possible accuracy.

8 Evaluate the following integral: **(7)**

$$\int_0^{\pi/2} (6 + 3\cos x)\, dx$$

(a) single application of Simpson's 1/3 rule
(b) multiple-application Simpson's 1/3 rule, with n = 4.

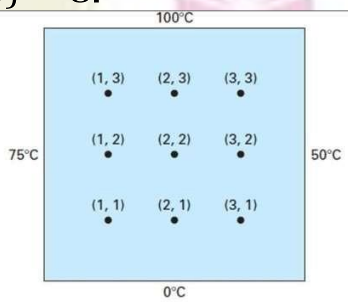
9 Solve the following initial value problem over the interval from t = 0 to 2 where y(0) = 1. Display all your results on the same graph. **(7)**

$$\frac{dy}{dt} = yt^2 - 1.1y$$

(a) Euler's method with h = 0.5 and 0.25.
(b) Fourth-order RK method with h = 0.5.

10 Use the shooting method to solve $7\, d^2y/dx^2 - 2\, dy/dx - y + x = 0$ with the boundary conditions y(0) = 5 and y(20) = 8. **(7)**

11 **(7)**



Use Liebmann's method (Gauss-Seidel) to solve for the temperature of the heated plate in figure. Employ overrelaxation with a value of 1.5 for the weighting factor and iterate to es $\varepsilon_s = 1\%$.

12	Use the simple implicit method to solve for the temperature distribution of a long, thin rod with a length of 10 cm and the following values: k' = 0.49 cal/(s . cm . ºC), Δx = 2 cm, and Δt = 0.1 s. At t =- O, the temperature of the rod is zero and the boundary conditions are fixed for all times at T(0) = 100ºC and T(10) = 50ºC. Note that the rod is aluminium with C = 0.2174 cal/(g . ºC) and ρ = 2.7 g/cm^3 . Therefore, k = 0.49/ (2.7 . 0.2174) 5 0.835 cm^2 /s and λ = 0.835(0.1)/(2)^2 = 0.020875.	**(7)**

Syllabus

Module 1

Introduction to Computational methods, system of equations- Revision - Formulation of engineering problems andsolution using computational methods; significant figures, accuracy, precision, round off error, truncation error, Taylor series expansion of a polynomial. Roots of equation - Bisection, Newton-Raphson, and Bairstow methods. Linear algebraic equations - Gauss Elimination method, LU decomposition. Non- linear equation- Gauss-Jordan method, Newton- Raphson for simultaneous equations. Case studies with computer programs (Python/Scilab/ C++/Fortran/other).

Module 2

Curve fitting- Linear regression- linearization of non linear relation, linear least squares, multiple linear regression. Non linear regression- polynomial regression, Gauss- Newton method. Case studies with computer programs (Python/Scilab/ C++/Fortran/other).

Module 3

Numerical differentiation and integration- Derivatives- Newton's forward, backward, divided difference and Sterling formula. Integration -Trapezoidal rule, Simpsons one third, Simpsons three eighth, Gauss quadrature-two & three point. Case studies with computer programs (Python/Scilab/ C++/Fortran/other).

Module 4

Numerical solutions to ordinary differential equations- Taylors method, Eulers method, Runge-Kutta method fourth order, simultaneous first order, Milne's predictor corrector. Initial value problem - shooting method, Eigen values - polynomial method, power method. Case studies with computer programs (Python/Scilab/ C++/Fortran/other).

Module 5

Solution of partial differential equation & Interpolation-

Interpolation - Newtons forward and backward, divided difference linear & quadratic, Lagrange interpolation, cubic splines, Hermites interpolation. Solution of partial differential equation - Difference equations, Elliptic equation- Laplace equation, Poisson equation, Liebmann's iterative methods, Parabolic equation- Bender-Schmidt method, simple implicit, Crank- Nicolson scheme, Solution of hyperbolic equation. Case studies with computer programs (Python/Scilab/ C++/Fortran/other).

Course Plan

No	Topic	No. of Lectures - 40 Hrs
1	**Introduction to Computational methods, system of equations**	
1.1	Revision - Formulation of engineering problems and solution using computational methods; significant figures, accuracy, precision, round off error, truncation error, Taylor series expansion of a polynomial	2
1.2	Roots of equation - Bisection, Newton Raphson, and Bairstow methods	2
1.3	Linear algebraic equations - Gauss Elimination method, LU decomposition. Non-linear equation- Gauss-Jordan method, Newton- Raphson for simultaneous equations	3
1.4	Case studies with computer programs (Python/Scilab/ C++/Fortran/other) (Not for End Semester Examination)	2
2	**Curve fitting**	
2.1	Linear regression- linearization of non linear relation, linear least squares, multiple linear regression	2
2.2	Non linear regression- polynomial regression, Gauss- Newton method	3
2.3	Case studies with computer programs (Python/Scilab/C++/Fortran/other) (Not for End Semester Examination)	2

3	**Numerical differentiation and integration**	
3.1	Derivatives - Newton's forward, backward, divided difference and Sterling formula	3
3.2	Integration -Trapezoidal rule, Simpsons one third, Simpsons three eighth, Gauss quadrature-two & three point.	3
3.3	Case studies with computer programs (Python/Scilab/ C++/Fortran/other) (Not for End Semester Examination)	2
4	**Numerical solutions to ordinary differential equations**	
4.1	Taylors method, Eulers method, Runge-Kutta method fourth order, simultaneous first order, Milne's predictor corrector	3
4.2	Initial value problem - shooting method, Eigen values -polynomial method, power method	3
4.3	Case studies with computer programs (Python/Scilab/C++/Fortran/other)(Not for End Semester Examination)	2
5	**Solution of partial differential equation & Interpolation**	
5.1	Interpolation - Newtons forward and backward, divided difference linear & quadratic, Lagrange interpolation, cubic splines, Hermites interpolation	3
5.2	Solution of partial differential equation - Difference equations, Elliptic equation-Laplace equation, Poisson equation, Liebmann's iterative methods, Parabolic equation- Bender-Schmidt method, simple implicit, Crank-Nicolson scheme, Solution of hyperbolic equation	3

5.3	Case studies with computer programs (Python/Scilab/ C++/Fortran/other)(Not for End Semester Examination)	2

Reference Books

1. Steven C. Chapra, Raymond P Canale, Numerical Methods for Engineering, 8e, Mc-Graw Hill Education (2020)
2. B.S. Grewal, numerical methods in engineering science with programs in C, C++ and MATLAB(10th edition) Khanna Publisher (2020)
3. E Balaguruswamy, Numerical Methods, McGraw Hill (2017)
4. P. Kandasamy , K. Thilagavathy and K. Gunavathy., Numerical Methods, S Chand & Co Ltd (2016)
5. S. P. Venkateshan, Prasanna Swaminathan, Computational Methods in Engineering, Ane Books (2014)
6. VN Vedamurthy & SN Iyengar, Numerical Methods, S Chand & Co Ltd (2014)
7. AK Jaiswal and Anju Khandelwal, Computer Based Numerical and Statistical Techniques, New Age International (2009)
8. Gilbert Strang, Computational Science and Engineering, Wellesley-Cambridge Press (2007)
9. Joe D Hoffman, Numerical Methods for Engineers and Scientists, Second Edition, Marcel Dekker (2001)

221TME003	ENERGY RESOURCES AND UTILIZATION	CATEGORY	L	T	P	CREDIT
		PROGRAM CORE 1	3	0	0	3

Preamble:

This course provides awareness about the availability and utilisation of conventional fuel reserves in India and the world and provides fundamental concepts about various renewable energy systems and devices with an emphasis on their technology.

Course Outcomes:

After the completion of the course the student will be able to

CO 1	Explain the present world and Indian energy scenario and the various renewable and non-renewable energy sources.
CO 2	Discuss the fundamental concepts of solar energy systems and devices.
CO 3	Illustrate the working of different types of stationary and sun tracking solar energy collectors.
CO 4	Explain the potential of wind energy and the working of wind energy conversion systems.
CO 5	Describe the working of OTEC system, geothermal energy system and different possible ways of extracting energy from ocean and biomass.

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7
CO 1	3	-	2	2	-	2	-
CO 2	3	-	2	2	-	2	-
CO 3	3	-	2	2	-	2	-
CO 4	3	-	2	2	-	2	-
CO 5	3	-	2	2	-	2	-

Assessment Pattern

Bloom's Category	End Semester Examination (marks)
Apply	20
Analyse	20
Evaluate	10
Create	10

Mark distribution

Total Marks	CIE	ESE	ESE Duration
100	40	60	2.5 hours

Continuous Internal Evaluation Pattern:

Micro project/Course based project : 20 marks

Course based task/Seminar/Quiz : 10 marks

Test paper, 1 no. : 10 marks

The project shall be done individually. Group projects not permitted. Test paper shall include minimum 80% of the syllabus.

End Semester Examination Pattern:

The end semester examination will be conducted by the University. There will be two parts; Part A and Part B. Part A contain 5 numerical questions (such questions shall be useful in the testing of knowledge, skills, comprehension, application, analysis, synthesis, evaluation and understanding of the students), with 1 question from each module, having 5 marks for each question. Students shall answer all questions. Part B contains 7 questions (such questions shall be useful in the testing of overall achievement and maturity of the students in a course, through long answer questions relating to theoretical/practical knowledge, derivations, problem solving and quantitative evaluation), with minimum one question from each module of which student shall answer any five. Each question can carry 7 marks. Total duration of the examination will be 150 minutes.

Model Question Paper

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY

FIRST SEMESTER M.TECH. DEGREE EXAMINATION

221TME003 – ENERGY RESOURCES AND UTILISATION

Max. Marks: 60 **Duration: 2.5 Hours**

PART A

Answer all questions

Each question carries 5 marks

1. The absorber surface of a solar collector is made of aluminum coated with black chrome (α_s = 0.87 and ϵ = 0.09). Solar radiation is incident on the surface at a rate of 720 W/m^2. The air and the effective sky temperatures are 25 and 15°C, respectively, and the convection heat transfer coefficient is 10 W/m^2·K. For an absorber surface temperature of 70°C, determine the net rate of solar energy delivered by the absorber plate to the water circulating behind it.

2. Calculate the angle made by beam radiation with the normal to a flat plate collector on May 1 at 09.00 h (local apparent time). The collector is located in New Delhi (28035’ N, 77012’ E). It is tilted at an angle of 36^0 with the horizontal and is pointing due south.

3. A wind turbine with a blade diameter of 27.4 m is to be installed in a location where average wind velocity is 6.1 m/s. The average temperature and pressure of ambient air in this location are 23.9 °C and 100 kPa. respectively. Gas constant of air is 287 J/kg.K. Determine the wind power potential.

4. a) Calculate the useful heat content per square kilometer of dry rock granite to a depth of 7 km. The geothermal temperature gradient G is constant at 40^0C/km. The minimum useful temperature for power

generation is 140 K more than the surface temperature T_0. ρ_r=2700 kg/m^3., C_r=820 $Jkg^{-1}K^{-1}$.

b) What is the time constant for useful heat extraction using a water flow rate of 1.0 $m^3s^{-1}km^{-2}$?

c) What is the useful heat extraction rate initially and after 10 years?

5. An open-system OTEC plant operates with a surface water temperature of 30°C and a deep water temperature of 10°C. The evaporator pressure is 3 kPa and condenser pressure is 1.5 kPa. The mass flow rate of warm surface water entering the evaporator is 100 kg/s and the turbine has an isentropic efficiency of 85 percent. Determine (a) the mass and volume flow rates of steam at the turbine inlet, (b) the turbine power output and the thermal efficiency of the plant. Neglect pumping power and other internal or auxiliary power consumptions in the plant

PART B

Answer any five questions

Each question carries 7 marks

6. a) List the various non-conventional energy resources. Explain their relative merits and demerits.

(5 Marks)

b) What are primary and secondary energy resources? Give examples

(2 Marks)

7. a) With the help of a neat sketch explain the components of a solar liquid flat plate collector? Discuss the critical requirements of cover plate and absorber plate for the efficient working of the collector?

(5 Marks)

b) Describe the important factors to be considered during the site selection of a wind turbine. (2 Marks)

8. a) In coastal areas, the difference between the daytime and night-time temperature is minimum. But in deserts, there is a large swing between the daytime and night-time temperatures. Explain?

(3 Marks)

b) With a neat sketch explain the working of a Thrombe wall passive solar heating system.

(4 Marks)

9. a) What is a selective surface, and why is it useful in solar water heating?

(2 Marks)

b) Calculate the overall loss coefficient for a flat plate collector with two glass covers. Given the following data.

Size of the absorber plate (L1 X L2) : 1.90 m X 0.90 m

Spacing between plate and first glass cover (L): 4 cm

Spacing between first and second glass cover (L) : 4 cm

Plate emissivity (ε_p) : 0.92

Glass cover emissivity (ε_c) : 0.88

Collector tilt(β) : 20^0

Mean plate temperature (T_{pm}) : 70^0C

Ambient air temperature (T_a) : 24^0C

Wind speed(V_∞) : 2.5 m/s

Back insulation thickness(δ_b) : 8 cm

Side insulation thickness(δ_s) : 4 cm

Thermal conductivity of insulation (k_i) : 0.05 W/m-K

(5 Marks)

10.a) Define thrust coefficient. Starting from the fundamentals, derive an expression for thrust coefficient in terms of axial interference factor.

(4 Marks)

b) With necessary sketches, explain dynamic matching of wind turbines

(3 Marks)

11.a) With a neat sketch, explain pyrolysis process. Discuss the range of conditions and products of pyrolysis.

(4 Marks)

b) Discuss two social advantages and two disadvantages of utilizing biofuels.

(3 Marks)

12.a) Explain the difference between spring and neap tides. Derive an expression for tidal energy per tidal cycle for a simple single-pool single effect tidal scheme.

(5 Marks)

b) Explain why OTEC is not feasible outside the tropics?

(2 Marks)

Syllabus

Module	Content	Hours
1	**Introduction to energy resources and utilization**: Forms of Energy, the importance of energy consumption as a measure of prosperity, Per Capita Energy Consumption. **Conventional and non-conventional energy resources**: Global and Indian energy scenario, Sector-wise energy consumption in the past, present and future. **Solar energy**: Availability and limitations; Sun-Earth angles; Sun path diagram; Solar radiation, Extraterrestrial solar radiation, Terrestrial irradiation; solar radiation on horizontal and inclined planes.	8
2	**Solar energy collectors**: stationary collectors-Flat plate collectors, Compound parabolic collectors, Evacuated tube collector; Sun tracking concentrating collectors: Parabolic trough collectors, Fresnel collectors, Parabolic dish collectors, Heliostat field collectors; Thermal analysis of flat plate collectors: Absorbed solar radiation, Collector energy analysis, Temperature distribution, Collector efficiency factor	7
3	**Wind energy**: availability; Turbine types: Horizontal axis machines, vertical axis machines, Concentrators; Linear momentum and basic theory: Energy extraction, Axial force, Torque, Drag machines; Dynamic matching: optimal rotation rate, tip speed ratio, Extensions for linear momentum theory; Blade element theory	7
4	**Energy from biomass**: Sources of biomass, Different species, Conversion of biomass into fuels; Energy through	9

	fermentation, Pyrolysis, gasification, combustion; Aerobic and anaerobic bioconversion: Types of biogas plants: Design and operation. **Geothermal energy**: Geophysics, Dry rock and hot aquifer analysis, Harnessing geothermal resources, Ground source heat pumps, Social and environmental aspects.	
5	Ocean thermal energy conversion (OTEC), Wave and tidal energy- Scope and economics, Introduction to integrated energy systems.	8

Course Plan

No	Topic	No. of Lectures
1	**MODULE 1**	**8**
1.1	Introduction to energy resources and utilization: Forms of Energy, the importance of energy consumption as a measure of prosperity, Per Capita Energy Consumption.	2
1.2	Conventional and non-conventional energy resources, Global and Indian energy scenario, Sector-wise energy consumption in the past, present and future.	2
1.3	Solar energy: Availability and limitations; Sun-Earth angles; Sun path diagram	1
1.4	Solar radiation, Extra-terrestrial solar radiation, Terrestrial irradiation	2
1.5	Solar radiation on horizontal and inclined planes.	1
2	**MODULE 2**	**7**
2.1	Solar energy collectors: stationary collectors-Flat plate collectors, Compound parabolic collectors, Evacuated tube collector	2
2.2	Sun tracking concentrating collectors: Parabolic trough collectors, Fresnel collectors, Parabolic dish collectors, Heliostat field collectors	2
2.3	Thermal analysis of flat plate collectors: Absorbed solar radiation, Collector energy analysis, Temperature distribution, Collector efficiency factor	3
3	**MODULE 3**	**7**
3.1	Wind energy: availability; Turbine types: Horizontal axis machines, vertical axis machines, Concentrators	1
3.2	Linear momentum and basic theory: Energy extraction, Axial force, Torque, Drag machines	2
3.3	Dynamic matching: optimal rotation rate, tip speed ratio, Extensions for linear momentum theory	2
3.4	Blade element theory: Calculation of lift and drag forces on a blade element, Calculation of forces and turning torque on a whole blade	2
4	**MODULE 4**	**9**
4.1	Energy from biomass: Sources of biomass, Different species	1
4.2	Conversion of biomass into fuels; Energy through fermentation, Pyrolysis, gasification and combustion	2

4.3	Aerobic and anaerobic bioconversion: Types of biogas plants: Design and operation.	2
4.4	Geothermal energy: Geophysics, Dry rock and hot aquifer analysis	2
4.5	Harnessing geothermal resources	1
4.6	Ground source heat pumps, Social and environmental aspects of geothermal power	1
5	**MODULE 5**	**8**
5.1	Ocean Thermal Energy Conversion (OTEC): Principles, Practical Considerations about OTEC	1
5.2	OTEC Devices; Social, economic and environmental aspects of OTEC	1
5.3	Wave Power: wave motion, wave energy and power	1
5.4	Real(irregular) sea waves: Patterns and power, Energy extraction from devices.	1
5.5	Wave power devices, Social, economic and environmental aspects of wave power	2
5.6	Tidal-current and tidal range power; The cause of tides, Enhancement of tides	1
5.7	Tidal current/stream power, Tidal range power, Social and environmental aspects of tidal power	1

Reference Books

1. World Energy Outlook 2021, International Energy Agency, 2021

2. Sukhatme, S.P., Nayak, J. K., Solar Energy, Tata McGraw Hill Publishing
   Company Ltd., New Delhi, 2017.

3. Jown Twidell., Renewable Energy Resources, Fourth Edition, Routledge, 2021.

4. Jefferson W., Tester et.al., Sustainable Energy: Choosing Among Options, The MIT Press, 2012.

5. Godfrey Boyle, Renewable Energy: Power for a Sustainable Future, Oxford University Press, 2012.

6. Tiwari G. N., Ghosal M. K., Fundamentals of renewable energy sources, Alpha Science International Ltd.

7. Roland Wengenmayr, Thomas Buhrke, Renewable Energy: Sustainable energy concepts for the future, Wiley – VCH, 2012.

221TME004	ENERGY CONVERSION SYSTEMS	Category	L	T	P	Credit
		PROGRAM CORE 2	3	0	0	3

Preamble: The focus of the course is to understand the general principles and technology of energy conversion systems in the context of Energy Management and Energy Engineering Systems

Course Outcomes:

After the completion of the course the student will be able to

CO 1	Understand the basic concepts of Thermodynamics
CO 2	Present a methodology of analysing energy systems
CO 3	Understand the gas turbine cycles and analyse gas turbine plants.
CO 4	Describe the nuclear energy conversion systems and technologies
CO 5	Describe different Hydrogen Energy Conversion Systems and their applications

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7
CO 1	2	-	-	1	2	-	-
CO 2	2	-	2	1	2	-	-
CO 3	3	-	2	1	2	-	-
CO 4	3	-	2	1	2	-	-
CO 5	3	-	2	1	2	-	-

Assessment Pattern

Bloom's Category	End Semester Examination(marks)
Apply	20
Analyse	20
Evaluate	10
Create	10

Mark distribution

Total Marks	CIE	ESE	ESE Duration
100	40	60	2.5 hours

Continuous Internal Evaluation Pattern:

Micro project/Course based project : 20 marks

Course based task/Seminar/Quiz : 10 marks

Test paper, 1 no. : 10 marks

The project shall be done individually. Group projects not permitted. Test paper
shall include minimum 80% of the syllabus.

End Semester Examination Pattern:

The end semester examination will be conducted by the University. There will be two parts; Part A and Part B. Part A contain 5 numerical questions (such questions shall be useful in the testing of knowledge, skills, comprehension, application, analysis, synthesis, evaluation and understanding of the students), with 1 question from each module, having 5 marks for each question. Students shall answer all questions. Part B contains 7 questions (such questions shall be useful in the testing of overall achievement and maturity of the students in a course, through long answer questions relating to theoretical/practical knowledge, derivations, problem solving and quantitative evaluation), with minimum one question from each module of which student shall answer any five. Each question can carry 7 marks. Total duration of the examination will be 150 minutes.

Model Question Paper

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY

FIRST SEMESTER M.TECH. DEGREE EXAMINATION

221TME004 – ENERGY CONVERSION SYSTEMS

Max. Marks: 60 **Duration: 2.5 Hours**

PART A

Answer all questions

Each question carries 5 marks

1. Air at 10°C and 80 kPa enters the diffuser of a jet engine steadily with a velocity of 200 m/s. The inlet area of the diffuser is 0.4 m^2. The air leaves the diffuser with a velocity that is very small compared with the inlet velocity. Determine (a) the mass flow rate of the air and (b) the temperature of the air leaving the diffuser.
2. Describe the challenges in operating a steam power plant based on Carnot cycle.
3. For a Brayton cycle with fixed maximum and minimum temperatures, how does the net work output vary with pressure ratio of the cycle?
4. What are the advantages and challenges of gas cooled reactors?
5. Discuss various chemical hydrogen energy conversion systems and their possible end-use outputs.

PART B

Answer any five questions

Each question carries 7 marks

6. 5 m^3 of air at 2 bar, 27°C is compressed up to 6 bar pressure following $pv^{1.3}$ = constant. It is subsequently expanded adiabatically to 2 bar. Considering the two processes to be reversible, determine the net work. Also plot the processes on T-S diagram.

7. A simple Rankine cycle works between pressures 28 bar and 0.06 bar, the initial condition of steam being dry saturated. Calculate the cycle efficiency, work ratio and specific steam consumption.
8. In a gas turbine plant working on the Brayton cycle, the air at the inlet is at 27^0 C and 0.1 MPa. The pressure ratio is 6.25 and the maximum temperature is 800^0C. The turbine and compressor isentropic efficiencies are both 80%. Find (a) the compressor work per kg or air (b) the turbine work per kg of air (c) the heat supplied per kg of air (d) the cycle efficiency and (e) the turbine exhaust temperature.
9. a) What is meant by uranium enrichment? Explain any one method of uranium enrichment with a neat sketch (4 Marks)

   b) Explain neutron economy and criticality in a nuclear reactor. (3 Marks)
10. What is a fast breeder reactor? Explain the pool type and looptype liquid metal fast breeder reactors with neat sketches.
11. Explain the working of a pressurizer used in PWR primary loopwith a neat sketch.
12. a) Explain the advantages and disadvantages of hydrogen as an energy source.

    b) With the help of a schematic diagram, explain a Solid Oxide Fuel Cell (SOFC) based cogeneration process.

Syllabus

Module	Content	Hours
1	Basics of Thermodynamics: First law of thermodynamics– Non flow energy equation - Gas processes – Constant pressure, Constant Volume, Isothermal, Adiabatic, and Polytropic process -Second law of thermodynamics – Carnot Cycle – Indicated and brake thermal efficiency calculations of IC engines – Steady Flow Energy Equations (SFEE) and its applications.	7
2	Steam flow processes: Steam plant -Rankine Cycle - Superheat – reheat – problems of steam cycles – regeneration - Losses in Steam Turbines – Methods for improving steam system performance.	7
3	**Gas turbine and combined cycle analysis** Gas Turbines: Classification of gas turbine plants, Optimum pressure ratio for maximum specific output in actual gas turbine plant. Inter-cooling, reheating and regeneration. Gas turbine cooling, design for high temperature, Combined cycles with heat recovery boiler, Combined cycles with multi-pressure steam, STAG combined cycle power plant, Influence of component efficiencies on cycle performance.	9
4	**Nuclear energy conversion** Chemical and nuclear equations, Nuclear reactions, Fission and fusion, Energy from fission and fuel burn-up, Radioactivity, Neutron energies, Fission reactor types. Nuclear power plants – Fast breeder reactor and power plants, Production of nuclear fuels.	9
5	Hydrogen Energy Conversion Systems: Combustion-Based Hydrogen Energy Conversion Systems, Chemical, Physical and Electrochemical Hydrogen Energy Conversion Systems, Hydrogen for Transportation Sector, Hydrogen for Portable Applications	8

Course Plan

No	Topic	No. of Lectures
1	**Basics of Thermodynamics**	**7**
1.1	First law of thermodynamics– Non flow energy equation - Gas processes – Constant pressure, Constant Volume, Isothermal, Adiabatic, and Polytropic process	3
1.2	Second law of thermodynamics – Carnot Cycle – Indicated and brake thermal efficiency calculations of IC engines	2
1.3	Steady Flow Energy Equations (SFEE) and its applications.	2
2	**Steam flow processes**	**7**
2.1	Steam plant -Rankine Cycle	2
2.2	Superheat – reheat – problems of steam cycles – regeneration - Losses in Steam Turbines	3
2.3	Methods for improving steam system performance.	2
3	**Gas Turbines**	**9**
3.1	Gas Turbines: Classification of gas turbine, simple open cycle gas turbine. Ideal and actual cycle (Brayton Cycle) for gas turbine	2
3.2	Optimum pressure ratio for maximum specific output in actual gas turbine regeneration	2
3.3	Inter-cooling, reheating and regeneration.	2
3.4	Gas turbine cooling, design for high temperature, Combined cycles with heat recovery boiler, Combined cycles with multi-pressure steam	2
3.5	STAG combined cycle power plant, Influence of component efficiencies on cycle performance.	1
4	**Nuclear energy conversion**	**9**
4.1	Chemical and nuclear equations, Nuclear reactions	2
4.2	Fission and fusion, Energy from fission and fuel burn-up, Radioactivity, Neutron energies.	3
4.3	Fission reactor types. Nuclear power plants – Fast breeder reactor and power plants	3
4.4	Production of nuclear fuels.	1
5	**Hydrogen Energy Conversion Systems**	**8**
5.1	Combustion-Based Hydrogen Energy Conversion Systems	2
5.2	Chemical, Physical and Electrochemical Hydrogen Energy Conversion Systems,	4
5.3	Hydrogen for Transportation Sector, Hydrogen for Portable Applications	2

Reference Books

1. M.M. E1- Wakil; Power Plant Technology, McGraw Hill, 1985.
2. A.W. Culp Jr; Principles of Energy Conversion, McGraw Hill, 2001.
3. H.A. Sorensen: Energy Conversion Systems, J. Wiley, 1983.
4. M.M. E1-Wakil: Nuclear Power Engineering, McGraw Hill, 1962.
5. R.H.S. Winterton: Thermal Design of Nuclear Reactors, Pergamon Press, 1981.
6. R.L. Murray: Introduction to Nuclear Engineering, Prentics Hall, 1961.
7. S.M. Yahya, Turbine compressors and Fans, TMH.
8. J. P. Holman, Thermodynamics, TMH Pub.
9. P. K. Nag, Power Plant Engineering, McGraw Hill Education.
10. Canan Acar, Ibrahim Dincer., Comprehensive Energy Systems, Elsevier, 2018

PROGRAM ELECTIVE I

221EME012	PROCESS RELIABILITY ENGINEERING	Category	L	T	P	Credit
		PROGRAM ELECTIVE 1	3	0	0	3

Preamble: The focus of the Process Reliability Engineering course is to familiarize students with the core concepts in Reliability Engineering and introduces them to the fundamentals of various reliability techniques and methodologies. These techniques include reliability prediction techniques, fault tree analysis, and reliability allocation in process systems.

Course Outcomes:

After the completion of the course the student will be able to

CO 1	Understand the basic concepts of reliability engineering.
CO 2	Understand and analyse the failure concept and models applicable in reliability engineering
CO 3	Draw Reliability Block diagrams for a given system configuration and there by evaluate system reliability
CO 4	Construct fault-tree for given system configurations and there by evaluate system reliability.
CO 5	Formulate and apply reliability concepts to engineering systems so as to improve the system reliability.

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7
CO 1	-	-	-	-	2	-	-
CO 2	-	-	-	-	2	-	-
CO 3	-	-	-	-	2	-	-
CO 4	-	-	-	-	2	-	-
CO 5	-	-	-	-	2	-	-

Assessment Pattern

Bloom's Category	End Semester Examination
Apply	25% (roughly)
Analyse	25% (roughly)
Evaluate	50% (roughly)
Create	-

Mark distribution

Total Marks	CIE	ESE	ESE Duration
100	40	60	2.5 hours

Continuous Internal Evaluation Pattern:

Preparing a review article based on peer reviewed original publications (minimum 10 publications shall be referred): 15 marks

Course based task/Seminar/Data collection and interpretation: 15 marks

Test paper, 1 no. : 10 marks

Test paper shall include minimum 80% of the syllabus.

End Semester Examination Pattern:

The end semester examination will be conducted by the respective College. There will be two parts; Part A and Part B. Part A will contain 5 numerical/short answer questions with 1 question from each module, having 5 marks for each question (such questions shall be useful in the testing of knowledge, skills, comprehension, application, analysis, synthesis, evaluation and understanding of the students). Students should answer all questions. Part B will contain 7 questions (such questions shall be useful in the testing of overall achievement and maturity of the students in a course, through long answer questions relating to theoretical/practical knowledge, derivations, problem solving and quantitative evaluation), with minimum one question from each module of which student should answer any five. Each question can carry 7 marks.

Note: The marks obtained for the ESE for an elective course shall not exceed 20% over the average ESE mark % for the core courses. ESE marks awarded to a student for each elective course shall be normalized accordingly. For example, if the average end semester mark % for a core course is 40, then the maximum eligible mark % for an elective course is 40+20 = 60 %.

Model Question Paper

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY

FIRST SEMESTER M.TECH. DEGREE EXAMINATION

221EME012 - PROCESS RELIABILITY ENGINEERING

Max. Marks: 60 **Duration: 2.5 Hours**

Part A
(Answer *all* questions – each question carries 5 marks)

1) Why does failure rate decrease in the early stages of a component's life?

2) Show that for a constant hazard model, failure rate is the reciprocal of Mean Time to Failure?

3) An element has a probability of successful operation of 60% over a given period of time. If 4 such components are connected in parallel estimate the improvement factor.

4) Explain the concept of reliability allocation.

5) How hot stand-by is different from cold standby?

(5 x 5 =25 marks)

Part B
(Answer *any* 5 questions – each question carries 7 marks)

6) Data given below indicates the results of tests conducted under severe conditions on 1000 safety valves.

Time interval	0-4	4-8	8-12	12-16	16-20	20-24
No. of failures	267	59	36	24	23	11

Obtain the failure density and hazard rates for various time intervals.

7) Derive expressions for reliability and failure density of a linearly increasing hazard model. Also sketch the variation of reliability and failure density wit respect to time.

8) The guidance system of a ship is controlled by a computer that has three major modules. In order for the computer to function properly,

all three modules must function. Two of the modules have reliability of 0.97, and the other has reliability of 0.99.

a. What is the reliability of the computer?

b. A backup computer identical to the one being used can be installed to improve overall reliability. Assuming that the new computer can automatically function if the first computer fails, determine the resulting reliability.

c. If the backup computer must be activated by a switch in the event that the first computer fails, and the switch has a reliability of 0.98, what is the overall reliability of the system?

9) One of the industrial robots designed by a leading producer has four major components. Components' reliability are 0.98, 0.95, 0.94, and 0.90. All of the components must function in order for the robot to operate effectively.

a. Calculate the reliability of the robot.

b. Designers want to improve the reliability of the robot by adding a backup component. Due to space limitations, only one backup can be added. The backup for any component will have the same reliability as the unit for which it is the backup. Which component should get the backup in order to achieve the highest reliability of the robot?

c. If one backup with a reliability of 0.92 can be added to any one of the main components, which component should get it to achieve the highest overall reliability?

10) A heavy current special machine demands continuous DC power supply during a particular period. The required power can be made available through a converter. In order to ensure uninterrupted supply, two converters are used, so that even if one fails the other converter provides the necessary current. The two converters receive their power supplies from a sub-station which is connected to the main grid. Construct the fault-tree for the system.

11) A system consists of three units connected in series with reliabilities 0.70, 0.80, and 0.90. It is desired that the reliability of the system be 0.65. How should this be allocated among the three units.

12) A product designer must decide if a redundant component is cost-justified in a product. The product in question has a critical component with a probability of 0.98 of operating. Product failure would involve a cost of $20,000. For a cost of $100, a switch and

backup component could be added that would automatically transfer the control to the backup component in the event of a failure. Should the backup component be added if its operating probability is also 0.98?

(5 x 7 =35 marks)

Syllabus

Module	Content	Hours
1	Definition of reliability – key elements; failure analysis – failure density – failure rate – probability of failure - bathtub curve - Basic reliability equations – Reliability in terms of – failure rate – failure density - relation between reliability, failure density and hazard rate - Mean time to failure (MTTF) – Integral equation of MTTF in terms of reliability	8
2	Hazard models – constant hazard model – linearly increasing hazard model – expressions for reliability, failure density, and probability of failure of these models – problems – Weibull Model.	8
3	System reliability – components connected in series – components connected in parallel – mixed configuration – reliability block diagrams (RBD) – distinction between physical configuration and logical configuration – problems	8
4	Fault Tree Analysis (FTA) – commonly used event representations – Fault tree construction – Estimation of system reliability from Fault Tree. Reliability allocation – evaluating improvements in component reliabilities to meet a system demand	8
5	Reliability improvement methods – Redundancy – unit redundancies – element redundancies – simplification of design – parts derating – operating environment; Cost of reliability – factors to be considered for optimizing the reliability cost	8

Course Plan

No	Topic	No. of Lectures
1	**Basics of Reliability**	
1.1	Definition of reliability – key elements; failure analysis – failure density – failure rate – probability of failure - bathtub curve.	3
1.2	Basic reliability equations – Reliability in terms of – failure rate – failure density - relation between reliability, failure density and hazard rate	3
1.3	Mean time to failure (MTTF) – Integral equation of MTTF in terms of reliability	2
2	**Hazard Models**	
2.1	Constant hazard model – linearly increasing hazard model – expressions for reliability, failure density, and probability of failure of these models - Problems	3
2.2	Weibull Model	1
2.3	Typical Problems	4
3	**System Reliability**	
3.1	Components connected in series – components connected in parallel	2
3.2	Mixed configuration- Distinction between physical configuration and logical configuration – problems	2
3.3	Typical problems	4
4	**Fault Tree Analysis and Reliability Allocation**	
4.1	Fault Tree Analysis (FTA) – commonly used event representations – Fault tree construction – Estimation of system reliability from Fault Tree.	3
4.2	Typical Problems	2
4.3	Reliability allocation – evaluating improvements in component reliabilities to meet a system demand	2
4.4	Typical Problems	1

5	**Reliability improvement methods**	
5.1	Redundancy – unit redundancies – element redundancies – simplification of design – parts derating – operating environment	6
5.2	Cost of reliability – factors to be considered for optimizing the reliability cost	2

Reference Books

1) Singiresu S. Rao, “Reliability Engineering”, Pearson India Services Pvt. Ltd., 2016

2) Alessandro Birolini, “Reliability Engineering: Theory and Practice”, Springer, 2010

3) Patrick D. T. O'Connor, Andre Kleyner, “Practical Reliability Engineering”, John Wiley & Sons, Ltd, 2012.

4) Lewis, E., “Introduction to Reliability Engineering”, John Wiley & Sons, 1995.

5) L. S. Srinath, “Reliability Engineering”, Affiliated East-West Press Ltd., 1985.

6) Charles E. Ebling, “Reliability & Maintainability Engg.”, Tata McGraw Hill Publishing Co., 1997.

221EME013	MANAGEMENT TOOLS IN ENGINEERING DESIGN	CATEGORY	L	T	P	CREDIT
		PROGRAM ELECTIVE 1	3	0	0	3

Preamble:

The focus of the Management tools in engineering design course is to introduce the core concepts of design management. It also emphasizes on familiarising students with various strategies and techniques used in the management of design projects. These techniques include project management methods, quality assurance, team management and decision making.

Course Outcomes:

After the completion of the course the student will be able to

CO 1	Understand and apply the various phases in design.
CO 2	Understand and apply the project management techniques in design process.
CO 3	Construct and analyse the quality control charts for quality assurance.
CO 4	Apply the problem-solving tools and evaluate the marketing models.
CO 5	Create decision making matrix for design management.

Mapping of course outcomes with program outcomes

	PO 1	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**
CO 1				2			
CO 2				2		3	
CO 3				-			2
CO 4				-	2		
CO 5				-		2	

Assessment Pattern

Bloom's Category	**End Semester Examination**
Apply	25% (roughly)
Analyse	25% (roughly)
Evaluate	25% (roughly)
Create	25% (Roughly)

Mark distribution

Total Marks	CIE	ESE	ESE Duration
100	40	60	2.5 hours

Continuous Internal Evaluation Pattern:

Preparing a review article based on peer reviewed original publications (minimum 10 publications shall be referred): 15 marks

Course based task/Seminar/Data collection and interpretation: 15 marks

Test paper, 1 no. : 10 marks

Test paper shall include minimum 80% of the syllabus.

End Semester Examination Pattern:

The end semester examination will be conducted by the respective College. There will be two parts; Part A and Part B. Part A will contain 5 numerical/short answer questions with 1 question from each module, having 5 marks for each question (such questions shall be useful in the testing of knowledge, skills, comprehension, application, analysis, synthesis, evaluation and understanding of the students). Students should answer all questions. Part B will contain 7 questions (such questions shall be useful in the testing of overall achievement and maturity of the students in a course, through long answer questions relating to theoretical/practical knowledge, derivations, problem solving and quantitative evaluation), with minimum one question from each module of which student should answer any five. Each question can carry 7 marks.

Note: The marks obtained for the ESE for an elective course shall not exceed 20% over the average ESE mark % for the core courses. ESE marks awarded to a student for each elective course shall be normalized accordingly. For example, if the average end semester mark % for a core course is 40, then the maximum eligible mark % for an elective course is 40+20 = 60 %.

Model Question paper

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY

FIRST SEMESTER M.TECH. DEGREE EXAMINATION

221EME013 – MANAGEMENT TOOLS IN ENGINEERING DESIGN

Max. Marks: 60 **Duration: 2.5 Hours**

Part A
(Answer *all* questions – each question carries 5 marks)

1) Identify the constraints in the 'Design of a sanitizer dispenser for public to be used in a village office.
2) Describe how a morphological chart can be used for generating design space
3) In a production process, a sample of 50 items is inspected on each day. The number of defective found in each sample is as follows: 1, 3, 4, 7, 9, 6, 13, 2, 5, 6. Draw an appropriate control chart and check for control.
4) What is the role of Pareto chart in cause finding in design?
5) Construct a simple personal decision tree (without probabilities) for whether to take an umbrella when you go to work on a cloudy day.

(5 x 5 =25 marks)

Part B
(Answer *any* 5 questions – each question carries 7 marks)

6) Develop a prescriptive model for various phases in the design of a step ladder..
7) Construct an appropriate control chart for the data given in Table, and comment on whether the process is under statistical control.

Lot no.	1	2	3	4	5	6	7	8	9	10
No. of inspected items	100	200	500	300	200	800	900	700	900	700

No. of defective items	19	16	7	43	77	86	33	53	86	91

8) A The number of defects in twenty pieces of vertical blind each of 10 m length is as follows: 1, 3, 2, 5, 2, 4, 3, 2, 1, 3, 2, 4, 6, 3, 5, 1, 1, 2, 2, 3. Draw an appropriate control chart, and conclude whether the process can be considered to be under statistical control.

9) Prepare a Cause-and-effect diagram for the production of flawed solder joints...

10) The MTTR and MTBF are 20 hrs and 50 hrs for a pump; The annual operating hr are 4000 and the hourly corrective maintenance labour cost is Rs 150. Calculate the annual corrective maintenance labour cost.

11) Four preliminary designs for sport-utility vehicles had the characteristics listed in the following table. First, see if you can get the same weighting factors as listed in the table.
Using the AHP method, suggest the most promising design?

Characteristics	Parameter	Weight factor	Design A	Design B	Design C	
Fuel Mileage	Miles/Gal.	0.175	20	16	15	
Range	Miles	0.075	300	240	260	
Comfort	Rating	0.40	poor	Good	Very good	
Easy to convert to 4-wheel drive	Rating	0.07	Very good	Very good	Poor	
Load Capacity	Pound	0.105	1000	700	1000	
Cost of repair	Av. of 5 parts	0.175	$ 700	$ 625	$ 700	

(5 x 7 =35 marks)

Syllabus

Module	Content	Hours
1	Introduction to design – Engineering design. Basic vocabulary in design, Challenges presented by the design environment– design failures – design types – qualities of a typical design engineer – Considerations of a good design, Codes and standards used in design.	**8**
2	Design Process – Various phases in design process – Formal design tools- design specifications – design reviews – design review phases , Managing a design project, Project management methods in design – CPM & PERT – probability of accomplishing the design project on stated date .	**8**
3	Quality control : Basics of control charts, Principle of control charts, Control chart in Quality assurance: Control charts in quality assurance, Process variability. Types of Shewhart Control Charts – variable control charts – X bar chart and R chart – attribute control charts –P chart – C chart	**8**
4	Problem solving in design: Problem solving tools in design: Problem definition, Cause finding, Solution finding. Applying problem solving tools in design, Flowchart, Cause-and-Effect Diagram, Interrelationship Digraph. Solution Finding and Implementation. Product marketing: Principles of marketing, Cost estimation models	**8**
5	Decision making and concept selection, Decision theory, Utility theory, Decision trees- Principles and illustration. Evaluation methods. Concept selection method, weighted decision matrix, Analytical Hierarchy process (AHP), AHP Process for Determining Criteria Weights, Consistency Check Process for AHP Comparison Matrix, Determining Ratings for Alternatives.	**8**

Course Plan

No	Topic	No. of Lectures
1	**Introduction to design**	
1.1	Engineering design, features of engineering design, Design objectives, design constraint, Functions, Means, Form	3
1.2	Challenges presented by the design environment– 4 Cs of design, design faults and design failures, causes of design failure, types of design- Original design, Adaptive design, Redesign, , Selection design , Industrial design.	3
1.3	Qualities of a typical design engineer – Considerations of a good design, Codes and standards used in design (Overview only).	2
2	**Design Process**	
2.1	Prescriptive model of design process, Problem definition Phase, Conceptual design Phase: Preliminary design Phase - Product Architecture, Configuration design, Parametric Design, Detailed design phase - Illustration	3
2.2	Design Review phase: Preliminary Design Review, Intermediate Design Review, Final Design Review, Team behaviour: Team Dynamics, Conflict management	2
2.3	Managing Design Projects, Tools for Managing design: Team Charter, Work breakdown structure, CPM & PERT – probability of accomplishing the design project on stated date: with examples	3
3	**Quality control**	
3.1	Basics of control charts, Principle of control charts, Control chart in Quality assurance: Principle of construction of control charts, control limits, statistical basis.	3
3.2	Analysis of Control Chart, Types of Shewhart Control Charts, Principles of control charts for variables and control charts for attributes	2
3.3	Construction of – variable control charts – X bar chart and R chart – attribute control charts –P chart np chart– C chart	3
4	**Problem solving in design**	
4.1	Problem solving tools in design: Problem definition	3

	Cause finding, Solution finding and implementation, applying problem solving tools in design,	
4.2	Flowchart, Cause-and-Effect Diagram, Interrelationship Digraph. Solution Finding and Implementation: How-How Diagram	2
4.3	Product marketing: Principles of marketing, 4Ps of marketing, Cost estimation models – cost capacity model – corrective maintenance model – software maintenance model – machining mode – cutting tool model – A C motor operating model – lighting model – Simple examples only	3
5	**Decision making and concept selection**	
5.1	Decision theory, Utility theory, Decision trees- Principles and illustration	2
5.2	Evaluation methods: Comparison based on absolute criteria- Evaluation based on judgment of feasibility of the design, Evaluation based on assessment of technology readiness, Evaluation based on go/no-go screening of the customer requirements	3
5.3	Plough concept selection method, weighted decision matrix, Analytical Hierarchy process (AHP), AHP Process for Determining Criteria Weights, Consistency Check Process for AHP Comparison Matrix, Determining Ratings for Alternatives	3

Reference Books

1. George E., Dieter G., Linda C. Schmidt “Engineering Design”, Mc Graw Hill, 4th Edition, 2009.
2. B.S. Dhillon, “Engineering Design: A Modern Approach”, Times Mirror Higher Education Group Inc. company, 1996
3. L.S. Srinath, “PERT And CPM Principles And Applications”, Affiliated East West Press, 2001

221EME014	ELECTRICAL ENERGY SYSTEMS	CATEGORY	L	T	P	CREDIT
		PROGRAM ELECTIVE 1	3	0	0	3

Preamble:

This course provides an intensive introduction to the AC system, AC system losses and power factor correction, operation and control of power system, solar and wind energy systems and energy storage techniques with an emphasis on their technology and applications.

Course Outcomes:

After the completion of the course the student will be able to

CO 1	Apply the concepts of AC system and electric power generation.
CO 2	Explain the concepts of transmission and distribution systems.
CO 3	Analyse power factor correction methods.
CO 4	Explain solar and wind energy systems and associated power electronic converters
CO 5	Explain various energy storage techniques, harmonics in power systems and EVs.

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7
CO 1	3	-	-	1	-	-	-
CO 2	3	-	2	1	-	-	-
CO 3	3	-	2	1	1	-	-
CO 4	3	-	2	1	-	2	-
CO 5	3	-	2	1	1	-	-

Assessment Pattern

Bloom's Category	End Semester Examination (%)
Apply	20
Analyse	20
Evaluate	10
Create	10

Mark distribution

Total Marks	CIE	ESE	ESE Duration

100	40	60	2.5 hours

Continuous Internal Evaluation Pattern:

Preparing a review article based on peer reviewed original publications (minimum 10 publications shall be referred): 15 marks

Course based task/Seminar/Data collection and interpretation: 15 marks

Test paper, 1 no. : 10 marks

Test paper shall include minimum 80% of the syllabus.

End Semester Examination Pattern:

The end semester examination will be conducted by the respective College. There will be two parts; Part A and Part B. Part A will contain 5 numerical/short answer questions with 1 question from each module, having 5 marks for each question (such questions shall be useful in the testing of knowledge, skills, comprehension, application, analysis, synthesis, evaluation and understanding of the students). Students should answer all questions. Part B will contain 7 questions (such questions shall be useful in the testing of overall achievement and maturity of the students in a course, through long answer questions relating to theoretical/practical knowledge, derivations, problem solving and quantitative evaluation), with minimum one question from each module of which student should answer any five. Each question can carry 7 marks.

Note: The marks obtained for the ESE for an elective course shall not exceed 20%over the average ESE mark % for the core courses. ESE marks awarded to a student for each elective course shall be normalized accordingly. For example, if the average end semester mark % for a core course is 40, then the maximum eligible mark % for an elective course is 40+20 = 60 %.

Model Question Paper

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY

FIRST SEMESTER M.TECH. DEGREE EXAMINATION

221EME014 – ELECTRICAL ENERGY SYSTEMS

Max. Marks: 60 **Duration: 2.5 Hours**

PART A

Answer all questions

Each question carries 5 marks

1. Explain the phenomena of corona and skin effect in transmission lines. Discuss various methods to reduce them.

2. Draw and explain the structure of conventional utility grid. Also, discuss the advantages and disadvantages of using high voltage transmission.

3. a) A 415 V, 55 kW, 50 Hz, 3ϕ induction motor runs at a power factor of 0.8 lag with an efficiency of 85 %. Find the capacitance of the capacitor bank to improve the supply power factor to 0.95.
   (3 Marks)

   b) What do you mean by penalty factor as referred to economic operation of power system?
   (2 Marks)

4. With the help of neat illustration, discuss the effect of variation of insolation and temperature on the performance of a solar cell.

5. With the help of a neat illustration and necessary chemical reactions, explain the operation of lead acid battery.

PART B

Answer any five questions

Each question carries 7 marks

6. a) A generation station of 1MW has the following demands:

From	To	Demand (kW)
Midnight	5 AM	100
5 AM	6 PM	300
6 PM	7 PM	700
7 PM	9 PM	800
9 PM	Midnight	300

Find load factor, PCF, PUF and utilization factor.

(4 Marks)

b) With the help of a neat illustration, explain the concept of microgrids. What are the advantages of microgrids over conventional grids?

(3 Marks)

7. Draw the nominal T and nominal π model of medium transmission lines and derive the expression for voltage regulation

8. Determine the economic operation schedule of a two-plant system to meet a load demand of 180 MW. The incremental fuel costs in ₹/MWh and losscoefficients of the two plants are given as

$$\frac{dC_1}{dP_1} = 2.0 + 0.01P_1$$

$$\frac{dC_2}{dP_2} = 1.5 + 0.01P_2$$

B_{11}=0.0015/MW; B_{12}=B_{21}=-0.0005/MW; B_{22}=0.0025/MW

9. a) Discuss about various power quality issues in power systems. Which is the different harmonic mitigation techniques used?

   b) Discuss about various collectors used in solar thermal systems.

10. With the help of the circuit diagram and waveforms, explain the operation of a 3ϕ full bridge inverter with 120° mode of operation.

11. Draw and explain various regions in the characteristics of a wind turbine. What is meant by tip speed ratio and what is its significance?

12. Discuss about different architectures of hybrid electric vehicles.

Syllabus

Module	Content	Hours
1	Review of AC system fundamentals, Indian power sector, the structure of power system, Sources of energy and various power generation schemes, Power system economics and tariff. Distributed Generation and smart grid- Introduction	7
2	Transmission and Distribution, Comparison of AC and DC transmission, Components of overhead transmission lines, Representation of power system components- Single line diagram, reactance diagram and per-unit system, Characteristics and performance of transmission lines. Corona, skin effect, Ferranti effect, proximity effect, transposition of conductors, bundled conductors, sag.	7
3	Concept of power factor and reactive power, causes and effects of low power factor, advantages of improved power factor, energy saving by power factor improvement through a capacitor, synchronous condenser. Active Shunt Compensators, Static Compensators and Flexible A.C. Transmission System.	6
4	Solar energy systems, wind energy conversion systems. Components of HAWT. Converters for grid-connected PV and wind energy systems- Half-bridge inverter, full-bridge inverter, sine PWM inverter. Maximum power point tracking in PV inverters	8
5	Energy Storage- Battery storage, Thermal Storage, Compressed air storage, pumped hydro storage, fuel cells, Flywheel –Super capacitors, Solar electrolytic hydrogen production. Electric and hybrid electric vehicles. Power quality issues- Problem of harmonics in power system, sources of harmonics, performance measures, harmonic mitigation.	7

Course Plan

No	Topic	No. of Lectures
1	**MODULE 1**	**7**
1.1	Review of AC system fundamentals	1
1.2	Indian power sector, the structure of power system	1
1.3	Sources of energy and various power generation schemes	2
1.4	Power system economics and tariff.	2
1.5	Distributed Generation and smart grid- Introduction	1
2	**MODULE 2**	**7**
2.1	Transmission and Distribution, Comparison of AC and DC transmission, Components of overhead transmission lines	2
2.2	Representation of power system components- Single line diagram, reactance diagram and per-unit system	2
2.3	Characteristics and performance of transmission lines. Corona, skin effect, Ferranti effect, proximity effect, transposition of conductors, bundled conductors, sag.	3
3	**MODULE 3**	**6**
3.1	Concept of power factor and reactive power	1
3.2	causes and effects of low power factor, advantages of improved power factor, energy saving by power factor improvement through a capacitor, synchronous condenser	3
3.3	Active Shunt Compensators, Static Compensators and Flexible A.C. Transmission System	2
4	**MODULE 4**	**8**
4.1	Solar energy systems	2
4.2	wind energy conversion systems, Components of HAWT.	2
4.3	Converters for grid-connected PV and wind energy systems- Half-bridge inverter, full-bridge inverter, sine PWM inverter.	3
4.4	Maximum power point tracking in PV inverters	1
5	**MODULE 5**	**7**
5.1	Energy Storage-Battery storage, Thermal Storage, Compressed air storage	1

5.2	Pumped hydro storage, fuel cells, Flywheel –Super capacitors, Solar electrolytic hydrogen production.	2
5.3	Electric and hybrid electric vehicles	1
5.4	Power quality issues- Problem of harmonics in power system	2
5.5	Sources of harmonics, performance measures, harmonic mitigation.	1

Reference Books

1. Nagrath I. J. and Kothari D. P., Power System Engineering, McGraw-Hill; 3rd Edition, 2019
2. Wadhwa C. L., Electrical Power Systems, New Age International (P) Limited Publishers, 7th Edition, 2017.
3. Gupta B.R., Power System Analysis and Design, S. Chand Publishing, 7th Edition, 1998.
4. D. P. Kothari, K. C. Singal, Rakesh Panjan, Renewable Energy Sources and Emerging Technologies, PHI, 2nd Edition, 2011.
5. Robert A. Huggins, Energy Storage, Springer, 2010.

221EME015	ELECTRIC VEHICLE SYSTEMS	CATEGORY	L	T	P	CREDIT
		PROGRAM ELECTIVE 1	3	0	0	3

Preamble:

This course aims to understand the fundamentals, theory and design of electric vehicles (EVs)

Course Outcomes:

After the completion of the course the student will be able to

CO 1	Understand the vehicle performance, power source characteristics, transmission characteristics, and equations used to describe vehicle performance.
CO 2	Understand the models, describe hybrid vehicles and their performance
CO 3	Describe the electric drives used in electric vehicles.
CO 4	Understand the different possible ways of energy storage.
CO 5	Explain the fundamentals of regenerative braking and fuel cells.

Mapping of course outcomes with program outcomes

	PO 1	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**
CO 1	3	3	2	2	-	2	1
CO 2	3	3	2	2	-	2	1
CO 3	3	3	3	2	1	2	1
CO 4	3	3	2	2	1	3	2
CO 5	3	3	2	2	1	2	2

Assessment Pattern

Bloom's Category	**End Semester Examination**
Apply	60%
Analyse	30%
Evaluate	10%
Create	

Mark distribution

Total Marks	CIE	ESE	ESE Duration
100	40	60	2.5 hours

Continuous Internal Evaluation Pattern: 40 marks

Preparing a review article based on peer reviewed original publications (minimum 10 publications shall be referred)	:	15 marks
Course based task/Seminar/Data collection an interpretation	:	15 marks
Test paper, 1 no.	:	10 marks

Test paper shall include minimum 80% of the syllabus. Evaluation shall only be based on application, analysis or design-based questions.

End Semester Examination Pattern:

The end semester examination will be conducted by the respective College. There will be two parts; Part A and Part B. Part A will contain 5 numerical/short answer questions with 1 question from each module, having 5 marks for each question (such questions shall be useful in the testing of knowledge, skills, comprehension, application, analysis, synthesis, evaluation and understanding of the students). Students should answer all questions. Part B will contain 7 questions (such questions shall be useful in the testing of overall achievement and maturity of the students in a course, through long answer questions relating to theoretical/practical knowledge, derivations, problem solving and quantitative evaluation), with minimum one question from each module of which student should answer any five. Each question can carry 7 marks.

Note: The marks obtained for the ESE for an elective course shall not exceed 20% over the average ESE mark % for the core courses. ESE marks awarded to a student for each elective course shall be normalized accordingly. For example, if the average end semester mark % for a core course is 40, then the maximum eligible mark % for an elective course is 40+20 = 60 %.

Model Question Paper

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY

221EME015 ELECTRIC VEHICLE SYSTEMS

Time: 2.5 hours Max. Marks: 60

PART-A

Answer *all* questions.

Each question carries *5 marks*.

1. Derive the dynamic equation of vehicle motion along the longitudinal direction?
2. With the necessary block diagram explain in detail about the configuration of electric vehicle?
3. Explain in detail about the principle and operation of the BLDC Motor?
4. Discuss the principle of super capacitor and mention the advantages of super capacitor over other energy storage devices for application in vehicle?
5. How does regenerative braking works?

PART-B

Answer *any five* questions.

Each question carries 7 marks

6. Explain rolling resistance and aerodynamic drag in vehicles
7. With necessary functional block diagram explain in detail about the series hybrid drive train configuration?
8. Explain the different power control modes of a typical parallel hybrid system with the help of block diagrams.
9. In what ways the switched reluctance motor is controlled? Explain it in detail with the block diagram

10. What is meant by C-rating of a battery? If a 2300m-AH is ratedas 0.5C, what would be its discharge current expressed as 0.5C.

11. What is Anti—lock braking system and why it is essential in vehicles? Explain its working?

12. Explain the Molten Carbonate Fuel Cells and Direct MethanolFuel Cells fuel cell technologies?

SYLLABUS

MODULE-I – Vehicle Fundamentals

General Description of Vehicle Movement, Vehicle Resistance: Rolling Resistance, Aerodynamic Drag, Grading Resistance. Dynamic Equation, Vehicle Power Plant and Transmission Characteristics, Vehicle Performance. Operating Fuel Economy, Braking Performance.

MODULE-II – EV & HEV Introduction

Electric Vehicles: Configurations of Electric Vehicles, Performance of Electric Vehicles: Traction Motor Characteristics, Tractive Effort and Transmission Requirement, Vehicle Performance.

Hybrid Electric Vehicles: Concept of Hybrid Electric Drive Trains, Architectures of Hybrid Electric Drive Trains, Series Hybrid Electric Drive Trains, Parallel Hybrid Electric Drive Trains, Power flow control modes.

MODUE-III – Electric Propulsion Systems

DC Motor Drives: Principle of Operation and Performance Combined Armature Voltage and Field Control, Chopper Control of DC Motors.

Induction Motor Drives: Principle of Induction Motors, Equivalent Circuit of Induction Motor, Speed Control of Induction Machine, Variable Frequency, Variable Voltage Control of Induction Motors,

Permanent Magnetic Brush-Less DC Motor Drives: Basic Principles of BLDC Motor Drives, BLDC Machine Construction and Classification, Performance Analysis and Control of BLDC Machines.

Switched Reluctance Motor Drives: Principle and operation, Converter Circuit, Types, Voltage Impulse Control, Current Impulse Control, Torque Control (Description with Block Diagram only)

MODULE-IV – Energy Storages

Energy Storages: Electrochemical Batteries: Electrochemical Reactions, Thermodynamic Voltage, Specific Energy and Power, Energy Efficiency, Battery Technologies: Lead-Acid Batteries, Nickel-based Batteries, Lithium-Based Batteries. Ultra-capacitors: Features of Ultra-capacitors, Basic Principles of Ultra-capacitors, Performance of Ultra-capacitors, Ultra-capacitor Technologies. Ultrahigh-Speed Flywheels: Operation Principles of Flywheels, Power Capacity of Flywheel Systems, Flywheel Technologies.

MODULE-V – Regenerative Braking and Fuel Cell Vehicles

Fundamentals of Regenerative Braking: Energy Consumption in Braking, Series Brake, Parallel Brake, Anti-lock Brake Systems

Fuel Cell Vehicles: Operating Principles of Fuel Cells, Fuel Cell Technologies: Proton Exchange Membrane Fuel Cells, Alkaline Fuel Cells, Phosphoric Acid Fuel Cells, Molten Carbonate Fuel Cells, Solid Oxide Fuel Cells, Direct Methanol Fuel Cells. Fuel Supply: Hydrogen Storage and Hydrogen Production, Non-hydrogen fuel cells.

Case Study: Design of Hybrid Electric Vehicles

Course Plan

No	Topic	No. of Lectures
1	**Vehicle Fundamentals**	
1.1	General Description of Vehicle Movement	1
1.2	Vehicle Resistance	2
1.3	Dynamic Equation	1
1.4	Vehicle Power Plant and Transmission Characteristics	1
1.5	Vehicle Performance	1
1.6	Operating Fuel Economy	1
1.7	Braking Performance	1
2	**EV & HEV Introduction**	
2.1	Configurations of Electric Vehicles	1
2.2	Traction Motor Characteristics, Tractive Effort and Transmission Requirement	2
2.3	Vehicle Performance	1
2.5	Concept of Hybrid Electric Drive Trains, Architectures of Hybrid Electric Drive Trains	1
2.6	Series Hybrid Electric Drive Trains, Parallel Hybrid Electric Drive Trains	2
2.7	Power flow Control modes	1
3	**Electric Propulsion Systems**	
3.1	Principle of Operation and Performance Combined Armature Voltage and Field Control	1
3.2	Control of DC Motors	1
3.3	Induction Motor Drives: Principle of Induction Motors, Equivalent Circuit of Induction Motor	1
3.4	Speed Control of Induction Machine, Variable Frequency, Variable Voltage Control of Induction Motors	2
3.5	Basic Principles of BLDC Motor Drives, BLDC Machine Construction and Classification	1
3.6	Performance Analysis and Control of BLDC Machines	1
3.7	Switched Reluctance Motor Drives: Principle and operation, Converter Circuit, Types	2
3.8	Voltage Impulse Control, Current Impulse Control, Torque Control	1
4	**Energy Storages**	
4.1	Electrochemical Batteries: Electrochemical Reactions,	2

	Thermodynamic Voltage, Specific Energy and Power, Energy Efficiency	
4.2	Battery Technologies: Lead-Acid Batteries, Nickel-based Batteries, Lithium-Based Batteries	2
4.3	Ultra-capacitors: Features of Ultra-capacitors, Basic Principles of Ultra-capacitors, Performance of Ultra-capacitors	1
4.4	Ultra-capacitor Technologies	1
4.5	Ultrahigh-Speed Flywheels: Operation Principles of Flywheels	1
4.6	Power Capacity of Flywheel Systems	1
4.7	Flywheel Technologies	1
5	**Regenerative Braking and Fuel Cell Vehicles**	
5.1	Fundamentals of Regenerative Braking: Energy Consumption in Braking	1
5.2	Series Brake, Parallel Brake, Anti-lock Brake Systems	2
5.3	Fuel Cell Vehicles: Operating Principles of Fuel Cells	1
5.4	Fuel Cell Technologies: Proton Exchange Membrane Fuel Cells, Alkaline Fuel Cells, Phosphoric Acid Fuel Cells, Molten Carbonate Fuel Cells, Solid Oxide Fuel Cells, Direct Methanol Fuel Cells.	3
5.5	Fuel Supply: Hydrogen Storage and Hydrogen Production	1
5.6	Non-hydrogen fuel cells	1
5.7	Case Study: Design of Hybrid Electric Vehicles	1

Reference Books

1. Modern Electric, Hybrid Electric, and Fuel Cell Vehicles, Fundamentals, Theory, and Design by Mehrdad Ehsani, Yimin Gao, Sebastian E Gay, Ali Emadi- CRC Press.

2. Hybrid Electric Vehicles: Principles and Applications with Practical Perspectives by Chris Mi, M. Abul Masrur, David Wenzhong Gao. A John Wiley & Sons Ltd.

3. T. Denton, “Electric and Hybrid Vehicles”, Routledge, 2016

221EME016	BIO-ENERGY TECHNOLOGIES	CATEGORY	L	T	P	CREDIT
		PROGRAM ELECTIVE 1	3	0	0	3

Preamble: Nil

Course Outcomes:

After the completion of the course the student will be able to

CO 1	Discuss the properties used for characterization of biomass
CO 2	Explain biofuels, preparation and applications
CO 3	Illustrate biological methods for energy conversion from biomass
CO 4	Discuss thermochemical methods for energy conversion from biomass
CO 5	Discuss the utilization of biomass in cook stoves, steam turbines, gas turbines and fuel cell

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7
CO 1	3	-	2	2	-	1	-
CO 2	3	-	2	2	-	1	-
CO 3	3	-	2	2	-	1	-
CO 4	3	-	2	2	2	1	-
CO 5	3	-	2	2	2	1	-

Assessment Pattern

Bloom's Category	End Semester Examination (%)
Apply	20
Analyse	20
Evaluate	10
Create	10

Mark distribution

Total Marks	CIE	ESE	ESE Duration
100	40	60	2.5 hours

Continuous Internal Evaluation Pattern: Total of 40 marks

Preparing a review article based on peer reviewed original publications (minimum 10 publications shall be referred): 15 marks
Course based task/Seminar/Data collection and interpretation: 15 marks
Test paper, 1 no.: 10 marks

Test paper shall include minimum 80% of the syllabus.

End Semester Examination Pattern:
The end semester examination will be conducted by the respective College. There will be two parts; Part A and Part B. Part A will contain 5 numerical/short answer questions with 1 question from each module, having 5 marks for each question (such questions shall be useful in the testing of knowledge, skills, comprehension, application, analysis, synthesis, evaluation and understanding of the students). Students should answer all questions. Part B will contain 7 questions (such questions shall be useful in the testing of overall achievement and maturity of the students in a course, through long answer questions relating to theoretical/practical knowledge, derivations, problem solving and quantitative evaluation), with minimum one question from each module of which student should answer any five. Each question can carry 7 marks.
Note: The marks obtained for the ESE for an elective course shall not exceed 20% over the average ESE mark % for the core courses. ESE marks awarded to a student for each elective course shall be normalized accordingly.

Model Question Paper

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY

FIRST SEMESTER M.TECH. DEGREE EXAMINATION

221EME016 – BIO ENERGY TECHNOLOGIES

Max. Marks: 60 **Duration: 2.5 Hours**

PART A

Answer all questions

Each question carries 5 marks

1. One gram of a biomass sample is heated at 105 ^oC for 24 h and the weight of the dried material is found as 0.85 g, which is further heated in a furnace at 950 ^oC for 7 min in absence of air by putting the lid of the crucible. The weight loss is found as 0.27 g. The remaining material is cooled with lid cover. When the temperature reaches to ambient temperature, its lid is opened and it is further heated in an oven at 750 ^oC for half an hour in presence of oxygen. After cooling the material, the residual mass of the material is found as 0.18 g. Determine the moisture content, volatile matter, ash and fixed carbon of the biomass.
2. Compare thermochemical and biological route of energy conversion from biomass.
3. Discuss the major impurities present in biogas and their effects.
4. Enumerate the difference between combustion, gasification and pyrolysis.
5. Explain the principle of gasifier cook stoves.

PART B

Answer any five questions

Each question carries 7 marks

6. 1.5 g of a biomass sample is kept in the bomb of a calorimeter. The initial and final temperatures of water in bucket are 25 and 29 ^oC respectively. The bucket wash is titrated against N/10 Na_2CO_3 and the titer value is 2.5 ml. Sulphur content in the biomass is 4 %. Parr 45 C

10 Ni Cr wire is used to ignite the biomass sample and 6 cm of the wire is fused. The water equivalent of the calorimeter is 2500 cal/ ^{o}C. Calculate the HHV of the biomass.

7. Why we can't use plant oils directly into IC engines? Explain the steps required for conversion of plant oil into biodiesel.

8. With the help of a figure explain the working of a floating drum type digester and enumerate the merits and demerits.

9. A biomass has the following composition on mass basis C 35%, H 10%, O 25%, N 0.5%, S 0.5%, Moisture 24% and Ash 5%. If the above biomass is gasified in a gasifier, what will be the composition of syngas when biomass to oxygen ratio is maintained as 0.8 (mass/mass) and steam to biomass ratio is maintained as 0.1 (mass/mass). Assume CO to H_2 ratio in syngas as 2:1 (vol/vol). Ignore the presence of other impurities and consider the molecular weight of the ash as 56.

10. Compare auger type and rotating cone type pyrolysis reactors.

11. With the help of a figure explain principle biomass based gasifier stove and enumerate the merits and demerits of forced convection stoves.

12. With the help of a figure explain biomass based steam powerplant.

Syllabus

Module 1

Introduction to Bioenergy- Energy mix in India and role of biomass in the energy mix, Characterization of biomass feedstock, Thermo-physical properties: Ultimate analysis and proximate analysis, Determination of ligno-cellulosic composition, Heating value, problems in Bomb calorie meter, Ash fusion temperature and its significance.

Module 2

Biofuels- Comparison of different routes of energy conversion from biomass, First, second and third generation of biofuels, Steps in biodiesel production, Transesterification, Ultrasound and microwave assisted transesterification, Supercritical method, Properties of biodiesel and comparison, Transesterification, Ultrasound and microwave assisted transesterification, Supercritical method, Properties of biodiesel and comparison, Ethanol production from biomass, Ethanol blending and application in IC engine.

Module 3

Biological methods for energy conversion-Anaerobic digestion, principle and steps, Types of digesters, fixed dome type digesters, Floating drum type digesters, Balloon type digesters, relative merits and demerits, Design of digester, Biogas impurities and their impact, Utilization of biogas, Fermentation process, dark fermentation, ABE fermentation.

Module 4

Thermochemical methods for energy conversion -Mechanism of combustion, air requirement for combustion, Types of combustion systems, Underfeed stoker, Grate firing, Rotary kiln, Fluidized bed combustion systems, Gasification, reactions and steps, Types of gasifier, Updraft gasifier, Downdraft gasifier, Fluidized bed gasifier, Entrained flow gasifier, Plasma gasifier, Numerical problems in air requirement and composition of combustion and gasification system, Pyrolysis principle, types of pyrolysis, properties of bio-oil, Application of biochar, Types of pyrolysis reactors, Fixed bed reactor, Fluidized bed reactor, Rotating cone reactor, Ablative reactor, Auger reactor, Vacuum reactor, Types of pyrolysis reactors, Fixed bed reactor, Fluidized bed reactor, Rotating cone reactor, Ablative reactor, Auger reactor, Vacuum reactor.

Module 5

Utilization of biomass in different applications- Biomass compaction, piston press, screw press, roller press and pillet mill, Biomass cook stoves, pellet gasifier stove, free convection and forced convection stoves, efficiency and emission, Biomass based steam powerplants, Biomass gasifier-gas turbine combined cycle, SOFC in bioenergy applications.

Course Plan

No	Topic	No. of Lectures
1	**Introduction to Bioenergy**	
1.1	Energy mix in India and role of biomass in the energy mix	1
1.2	Characterization of biomass feedstock	1
1.3	Thermo-physical properties: Ultimate analysis and proximate analysis	2
1.4	Determination of ligno-cellulosic composition	1
1.5	Heating value, problems in Bomb calorie meter	2
1.6	Ash fusion temperature and its significance	1
2	**Biofuels**	
2.1	Comparison of different routes of energy conversion from biomass	1
2.2	First, second and third generation of biofuels	1
2.3	Steps in biodiesel production	1
2.4	Transesterification, Ultrasound and microwave assisted transesterification, Supercritical method	2
2.5	Properties of biodiesel and comparison	1
2.6	Ethanol production from biomass	1
2.7	Ethanol blending and application in IC engine	1
3	**Biological methods for energy conversion**	
3.1	Anaerobic digestion, principle and steps	1
3.2	Types of digesters, fixed dome type digesters	1
3.3	Floating drum type digesters, Balloon type digesters, relative merits and demerits	2
3.4	Design of digester	2
3.5	Biogas impurities and their impact, Utilization of biogas	1
3.6	Fermentation process, dark fermentation, ABE fermentation	1
4	**Thermochemical methods for energy conversion**	
4.1	Mechanism of combustion, air requirement for combustion,	1
4.2	Types of combustion systems, Underfeed stoker, Grate firing, Rotary kiln, Fluidized bed combustion systems	1
4.3	Gasification, reactions and steps	1
4.4	Types of gasifier, Updraft gasifier, Downdraft gasifier, Fluidized bed gasifier, Entrained flow gasifier, Plasma gasifier	2

4.5	Numerical problems in air requirement and composition of combustion and gasification system	1
4.6	Pyrolysis principle, types of pyrolysis, properties of bio-oil, Application of biochar	1
4.7	Types of pyrolysis reactors, Fixed bed reactor, Fluidized bed reactor, Rotating cone reactor, Ablative reactor, Auger reactor, Vacuum reactor	1
5	**Utilization of biomass in different applications**	
5.1	Biomass compaction, piston press, screw press, roller press and pillet mill	2
5.2	Biomass cook stoves, pellet gasifier stove, free convection and forced convection stoves, efficiency and emission	2
5.3	Biomass based steam powerplants	1
5.4	Biomass gasifier-gas turbine combined cycle	1
5.5	SOFC in bioenergy applications	2

Reference Books

1. Jay J. C., “Biomass to Renewable Energy Processes”, Taylor and Francis, CRC Press

2. Konur O., “Bioenergy and Biofuels”, Taylor and Francis, CRC Press

3. Mukunda, H. S., “Understanding Clean Energy and Fuels from Biomass”, Wiley India

4. Love J. and Bryant J. A., “Biofuels and Bioenergy”, John Wiley & Sons

221EME017	ADVANCED ENERGY MATERIALS	CATEGORY	L	T	P	CREDIT
		PROGRAM ELECTIVE 1	3	0	0	3

Preamble:

This course is a materials science approach to the challenge of energy-efficient technology. It focuses on materials energy content and describes how advanced materials make possible efficient energy harvesting, and energy storage. The intended course in addition provides the principles of advanced materials processing and their characterization techniques.

Course Outcomes: After the completion of the course the student will be able to

CO 1	Understand the concepts of materials used in photovoltaics
CO 2	Analyze different materials used for energy harvesting and energy storage
CO 3	Apply the basic principles advanced processing techniques for developing energy materials.
CO 4	Apply the fundamental concepts of characterization techniques used for energy materials.
CO 5	Define and differentiate suitable advanced energy materials engineering materials for engineering applications.

Mapping of course outcomes with program outcomes

	PO 1	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**
CO 1	3						
CO 2		3					
CO 3					3		
CO 4				3			
CO 5			2				

Assessment Pattern

Bloom's Category	**End Semester Examination (marks)**
Apply	20
Analyse	20

Evaluate	10
Create	10

Mark distribution

Total Marks	CIE	ESE	ESE Duration
100	40	60	2.5 hours

Continuous Internal Evaluation Pattern: 40 marks

Preparing a review article based on peer reviewed original publications (minimum 10 publications shall be referred)	: 15 marks
Course based task/Seminar/Data collection an interpretation	: 15 marks
Test paper, 1 no.	: 10 marks

Test paper shall include minimum 80% of the syllabus. Evaluation shall only be based on application, analysis or design-based questions.

End Semester Examination Pattern:

The end semester examination will be conducted by the respective College. There will be two parts; Part A and Part B. Part A will contain 5 numerical/short answer questions with 1 question from each module, having 5 marks for each question (such questions shall be useful in the testing of knowledge, skills, comprehension, application, analysis, synthesis, evaluation and understanding of the students). Students should answer all questions. Part B will contain 7 questions (such questions shall be useful in the testing of overall achievement and maturity of the students in a course, through long answer questions relating to theoretical/practical knowledge, derivations, problem solving and quantitative evaluation), with minimum one question from each module of which student should answer any five. Each question can carry 7 marks.

Note: The marks obtained for the ESE for an elective course shall not exceed 20% over the average ESE mark % for the core courses. ESE marks awarded to a student for each elective course shall be normalized accordingly.

Model Question Paper

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY

FIRST SEMESTER M.TECH. DEGREE EXAMINATION

221EME017 – ADVANCED ENERGY MATERIALS

Max. Marks: 60 **Duration: 2.5 Hours**

PART A

Answer all questions

Each question carries 5 marks

1. Differentiate first generation and second-generation solar cell materials.
2. What are metamaterials?
3. Explain the characteristics of hydrogen storage materials used in fuel cells.
4. Discuss chemical vapour deposition.
5. Point out the applications of energy dispersive spectroscopy.

5x 5 Marks= 25Marks

PARTB

Answer Any Five Questions

Each question carries 7 marks

6. Discuss thin film processing for solar cells. What are the properties required for thin film materials?
7. Explain in detail about the various materials used for energy harvesting.
8. Explain about the synthesis of hydrocarbons.
9. With neat sketches explain the material synthesis process by molecular beam epitaxy.
10. What are the various steps involved in typical chemical vapour deposition technique for the synthesis of advanced energy materials? Differentiate between colloidal and solgel method.

11. Compare the working of transmission electron microscope and scanning tunneling microscope.
12. With neat sketches explain Raman spectroscopic technique for characterization of energy materials.

5X7 Marks = 35 Marks

Syllabus

Module-1

Materials for photovoltaics - First generation solar cell materials; single and polycrystalline Silicon, Contact materials, materials for surface Engineering, Second generation solar cell materials; CdSe, CdTe, Copper Indium Gallium Selenide (CIGS), Gallium Arsenide for applications in photovoltaics, Materials for thin film solar cells, Thin film processing, and properties. Third generation solar cell materials; Quantum Dots, Organic materials, Composites, Dyes, Perovskites and their synthesis, characterization and properties.

Module-2

Materials for energy harvesting: Piezoelectric materials, Pyro electric and Thermo-electrics materials, Electrostatic (capacitive) Energy Harvesting and materials, Energy from Magnetic Induction, Meta material, Energy from atmospheric pressure changes, Electro active polymers (EAPs), Nano generators, Electro active polymers (EAPs), Nano generators, Ambient radiation sources and Nano antenna, energy from noise.

Module-3

Materials for Energy Storage - Electrochemistry and electro-chemical Battery materials, Hydrogen Storage materials for fuel cells: Metal hybrids, Nanostructured metal hydrides, Non-metal hydrides, Carbohydrates, Synthesis of hydrocarbons, Aluminum, Liquid organic hydrogen carriers (LOHC), Ammonia, Amine borane complexes, Nano borohydrides and nano catalyst doping, Imidazolium ionic liquids, phosphonium borate, Carbonite substances, Metal Organic frameworks, Activated Carbons, Carbon nanotubes, Clathrate hydrates, Glass capillary arrays.

Module-4

Materials Synthesis Methods Physical Methods - Vacuum Evaporation, Electron beam evaporation Sputtering, Cathodic Arc Deposition and Chemical Vapour Deposition, Atomic Layer Deposition, Pulsed Laser Deposition, Molecular Beam Epitaxy, Lithography and their types, Chemical Methods; Sol-Gel technique, self-assembly, colloidal method, Hydro-thermal method, co-precipitation method, Solid state synthesis, microwave method, micro-emulsion method.

Module-5

Materials Characterization Methods - Transmission electron microscope, Scanning electron microscopes, Raman spectroscopy, Scanning tunneling Microscopy, Atomic Force Microscopy, Thermal analysis: DTA, DSC. Characteristics of X-rays, X- ray Fluorescence Spectrometry, Wavelength Dispersive Spectroscopy, Energy Dispersive Spectroscopy - Instrumentation, Working procedure, Applications, Limitations.

Course Plan

No	Topic	No. of Lectures
1	**Module-1**	
1.1	Materials for photovoltaics - First generation solar cell materials; single and polycrystalline Silicon	**1**
1.2	Contact materials, materials for surface engineering	**1**
1.3	Second generation solar cell materials; CdSe, CdTe	**1**
1.4	Copper Indium Gallium Selenide (CIGS), Gallium Arsenide for applications in photovoltaics,	**1**
1.5	Materials for thin film solar cells, Thin film processing, and properties.	**1**
1.6	Third generation solar cell materials; Quantum Dots,	**1**
1.7	Organic materials, Composites, Dyes	**1**
1.8	Perovskites and their synthesis, characterization and properties.	**1**
2	**Module-2**	
2.1	Materials for energy harvesting: Piezoelectric materials	**1**
2.2	Pyro electric and Thermo-electrics materials	**1**
2.3	Electrostatic (capacitive) Energy Harvesting and materials	**1**
2.4	Energy from Magnetic Induction, Meta material	**1**
2.5	Energy from atmospheric pressure changes	**1**
2.6	Electro active polymers (EAPs), Nano generators	**1**
2.7	Ambient radiation sources and Nano antenna, energy from noise.	**2**
3	**Module-3**	
3.1	Materials for Energy Storage - Electrochemistry and electro-chemical Battery materials	**1**
3.2	Hydrogen Storage materials for fuel cells: Metal hybrids, Nanostructured metal hydrides,	**1**
3.3	Non-metal hydrides, Carbohydrates, Synthesis of hydrocarbons,	**1**
3.4	Aluminum, Liquid organic hydrogen carriers (LOHC), Ammonia, Amine borane complexes,	**1**
3.5	Nano borohydrides and nano catalyst doping,	**1**
3.6	Imidazolium ionic liquids, phosphonium borate, Carbonite substances	**1**
3.7	Metal Organic frameworks, Activated Carbons	**1**

3.8	Carbon nanotubes, Clathrate hydrates, Glass capillary arrays.	**1**
4	**Module 4**	
4.1	Materials Synthesis Methods Physical Methods - Vacuum Evaporation, Electron beam evaporation Sputtering	**1**
4.2	Cathodic Arc Deposition and Chemical Vapour Deposition	**1**
4.3	Atomic Layer Deposition, Pulsed Laser Deposition	**1**
4.4	Molecular Beam Epitaxy, Lithography and their types	**1**
4.5	Chemical Methods; Sol-Gel technique, self-assembly, colloidal method,	**2**
4.6	Hydro-thermal method, co-precipitation method,	**1**
4.7	Solid state synthesis, microwave method, micro-emulsion method.	**1**
5	**Module-5**	
5.1	Materials Characterization Methods - Transmission electron microscope	**1**
5.2	Scanning electron microscopes	**1**
5.3	Raman spectroscopy	**1**
5.4	Scanning tunneling Microscopy	**1**
5.5	Atomic Force Microscopy	**1**
5.6	Thermal analysis: DTA, DSC.	**1**
5.7	Characteristics of X-rays, X- ray Fluorescence Spectrometry, Wavelength Dispersive Spectroscopy	**1**
5.8	Energy Dispersive Spectroscopy - Instrumentation, Working procedure, Applications, Limitations.	**1**

Reference Books

1. Advanced Energy Materials, Ashutosh Tiwari & Sergiy Valyukh, J. Wiley & Sons
2. Eco-And Renewable Energy Materials, Young Zho, Springer
3. Materials And Energy (Book Series), Leonard C Feldman (Ed. In Chief), World Scientific
4. Solar Cells: Operating Principles, Technology And System Applications By Martin A Green, Prentice Hall Inc, Englewood Cliffs, Nj, Usa, 1981.
5. Clean Electricity From Photovoltaics, M. D. Archer, R. Hill, Imperial College Press, 2001.
6. Carbon Nanotubes And Related Structures: New Material For Twenty First Century, Pjf Harris, Cambridge University Press, 1999.
7. Seminconductors For Solar Cells, H. J. Moller, Artech House Inc, Ma, Usa, 1993. Solid State Electronic Devices, Ben G. Streetman, Prentice-Hall Of India Pvt. Ltd., New Delhi 1995.

PROGRAM ELECTIVE II

221EME018	ENVIRONMENTAL ENGINEERING	CATEGORY	L	T	P	CREDIT
		PROGRAM ELECTIVE 2	3	0	0	3

Preamble: Nil

Course Outcome:

After the completion of the course the student will be able to

CO 1	Explain material balance and energy balance of environmental systems
CO 2	Discuss environmental chemistry and risk assessment in environmental problems
CO 3	Explain the cause, measurement and treatment of water pollution
CO 4	Illustrate air pollution and meteorology
CO 5	Discuss solid waste management techniques

Mapping of course outcomes with program outcomes

	PO 1	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**
CO 1	3	1	2	-	-	1	-
CO 2	3	1	2	-	-	1	-
CO 3	3	1	2	-	-	1	-
CO 4	3	1	2	-	-	1	-
CO 5	3	1	2	-	-	1	-

Assessment Pattern

Bloom's Category	**End Semester Examination (%)**
Apply	30
Analyse	30
Evaluate	30
Create	10

Mark distribution

Total Marks	**CIE**	**ESE**	**ESE Duration**
100	40	60	2.5 hours

Continuous Internal Evaluation: 40 marks

Preparing a review article based on peer reviewed original publications (minimum 10 publications shall be referred): 15 marks

Course based task/Seminar/Data collection and interpretation: 15 marks

Test paper, 1 no.: 10 marks

Test paper shall include minimum 80% of the syllabus.

End Semester Examination Pattern: 60 marks

The end semester examination will be conducted by the respective College. There will be two parts; Part A and Part B. Part A will contain 5 numerical/short answer questions with 1 question from each module, having 5 marks for each question (such questions shall be useful in the testing of knowledge, skills, comprehension, application, analysis, synthesis, evaluation and understanding of the students). Students should answer all questions. Part B will contain 7 questions (such questions shall be useful in the testing of overall achievement and maturity of the students in a course, through long answer questions relating to theoretical/practical knowledge, derivations, problem solving and quantitative evaluation), with minimum one question from each module of which student should answer any five. Each question can carry 7 marks.

Note: The marks obtained for the ESE for an elective course shall not exceed 20% over the average ESE mark % for the core courses. ESE marks awarded to a student for each elective course shall be normalized accordingly. For example if the average end semester mark % for a core course is 40, then the maximum eligible mark % for an elective course is 40+20 = 60 %.

Model Question paper

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY

FIRST SEMESTER M.TECH. DEGREE EXAMINATION

221EME018 – ENVIRONMENTAL ENGINEERING

Max. Marks: 60 **Duration: 2.5 Hours**

PART A

Answer all questions

Each question carries 5 marks

1. Worldwide combustion of methane, (CH_4), provides about 10.9 x 10^{16} kJ of energy per year. If methane has an energy content of 39 x 10^3 kJ/m^3 (at STP) what mass of CO_2 is emitted into the atmosphere each year? Also express that emission rate as metric tons of carbon per year?
2. Discuss the application of Henry's law in waste water treatment plant.
3. With the help of figures explain different smokestack plume behaviour.
4. Explain the procedure for determining BOD of a sample.
5. With suitable example explain life cycle assessment.

PART B

Answer any five questions

Each question carries 7 marks

6. Consider a 10 x 10^6 m^3 lake fed by a polluted stream having a flow rate of 5 m^3/s and pollutant concentration equal to 10 mg/L. There is also a sewage outfall that discharges 0.5 m^3/s of wastewater having a pollutant concentration of 100 mg/L. The stream and sewage wastes have a decay rate coefficient of 0.20 /day. Assuming the pollutant is completely mixed in the lake and assuming no evaporation or other water losses or gains, find the steady state pollutant concentration in the lake. If it is decided to completely divert the sewage outfall from the lake, eliminating it as a source of pollution. Find the concentration

of pollutant in the lake one week after the diversion, and find the new final steady state concentration.

7. A bar with volume 500 m^3 has 50 smokers in it, each smoking 2 cigarettes per hour. An individual cigarette emits, among other things, about 1.4 mg of formaldehyde(HCHO). Formaldehyde converts to carbon dioxide with a reaction rate coefficient k = 0.40 /hr. Fresh air enters the bar at the rate of 1000 m^3 / hr and stale air leaves at the same rate. Assuming complete mixing, estimate the steady state concentration of formaldehyde in the air. At 1 atm and 25 ^oC how does the result compare with the threshold for eye irritation of 0.05 ppm?

8. Explain the different steps of risk assessment.

9. A wastewater treatment plant serving a city discharges 1.10 m^3/s of treated effluent having an ultimate BOD of 50.0 mg/L into a stream that has a flow of 8.70 m^3/s and a BOD of its own equal to 6.0 mg/L. The deoxygenation constant, is 0.20/day. Assuming complete and instantaneous mixing, estimate the ultimate BOD of the river just downstream from the outfall. If the stream has a constant cross section, so that it flows at a fixed speed equal to 0.20 m/s, estimate the BOD remaining in the stream at a distance 40,000 m downstream.

10. Discuss different types of atmospheric stability conditions based on adiabatic lapse rate and explain the causes of temperature inversions.

11. Discuss the environmental impacts of waste to energy conversions.

12. a) Find the settling velocity of a spherical droplet of water with 4 micrometer diameter and estimate the residence time of such particles if they are uniformly distributed in the lower 1,000 m of atmosphere and their removal rate is determined by how fast they settle in still air. Assume viscosity of water as 8.9 x 10^{-4} Ns/m^2.

(4 marks)

b) Discuss how carbon monoxide interferes with bloods ability to carry oxygen. **(3 marks)**

Syllabus

Module 1

Material balance and energy balance of environmental systems- Material balance of steady state conservative systems, batch system with nonconservative pollutants, steady state system with Nonconservative pollutants, Step function response, First law of thermodynamics applied to environmental engineering systems, Second law of thermodynamics applied to environmental engineering systems.

Module 2

Environmental chemistry and risk assessment- Stoichiometry, Enthalpy in chemical systems, Chemical equilibrium, acid-base reactions, solubility of gases in water, carbonate system, Importance of Organic chemistry and nuclear chemistry in environmental engineering, Risk assessment, hazard identification, dose response assessment, human response assessment.

Module 3

Water pollution- Unusual properties of water, hydrologic cycle, water resources and water usage, Water pollutants; pathogens, oxygen demanding wastes, nutrients, salts, thermal pollution, pesticides, heavy metals, volatile organic chemicals and emerging contaminants, Biochemical oxygen demand, five day BOD test, modelling BOD as a first order reaction, BOD reaction rate constant, COD, Effect of oxygen demanding wastes in river, Water treatment systems, sedimentation, coagulation and flocculation, filtration, disinfection, membrane process, Wastewater treatment, primary treatment, secondary or biological treatment, suspended growth treatment, attached growth treatment, sludge treatment, nutrient removal, Hazardous waste treatment technologies, physical treatment, chemical treatment, biological treatment.

Module 4

Criteria pollutants and their effects, carbon monoxide, oxides of nitrogen, volatile organic compounds, photochemical smog and ozone, particulate matter, oxides of sulphur and lead, Meteorology: adiabatic lapse rate, atmospheric stability, temperature inversions and mixing depths, Smokestack plume and adiabatic lapse rate, point source Gaussian plume model, dispersion coefficients, line source model, area source model, Automobile emissions, emission standard, emission control methods, Stationary emissions, coal fired powerplants, precombustion controls, fluidized bed combustion, IGCC, fluegas scrubbers, cyclone collectors, electrostatic precipitators

Module 5

Source reduction, material selection, material life extension, process management, efficient distribution, Life cycle assessment, Recycling; paper and paper board recycling, plastic recycling, aluminium and other metal recycling, Composting, waste to energy conversions, landfills, Material recovering fecilities and economics.

Course Plan

No	Topic	No. of Lectures
1	**Material balance and energy balance of environmental systems**	
1.1	Material balance of steady state conservative systems, batch system with nonconservative pollutants, steady state system with Nonconservative pollutants	3
1.2	Step function response	1
1.3	First law of thermodynamics applied to environmental engineering systems	2
1.4	Second law of thermodynamics applied to environmental engineering systems	2
2	**Environmental chemistry and risk assessment**	
2.1	Stoichiometry	1
2.2	Enthalpy in chemical systems	1
2.3	Chemical equilibrium, acid-base reactions, solubility of gases in water, carbonate system	2
2.4	Importance of Organic chemistry and nuclear chemistry in environmental engineering	2
2.5	Risk assessment, hazard identification, dose response assessment, human response assessment	2
3	**Water pollution**	
3.1	Unusual properties of water, hydrologic cycle, water resources and water usage	1
3.2	Water pollutants; pathogens, oxygen demanding wastes, nutrients, salts, thermal pollution, pesticides, heavy metals, volatile organic chemicals and emerging contaminants	1
3.3	Biochemical oxygen demand, five day BOD test, modelling BOD as a first order reaction, BOD reaction rate constant, COD	1
3.4	Effect of oxygen demanding wastes in river	1
3.5	Water treatment systems, sedimentation, coagulation and flocculation, filtration, disinfection, membrane process	1
3.6	Wastewater treatment, primary treatment, secondary or biological treatment, suspended growth treatment, attached growth treatment, sludge treatment, nutrient removal	2
3.7	Hazardous waste treatment technologies, physical treatment, chemical treatment, biological treatment	1

4	**Air pollution**	
4.1	Criteria pollutants and their effects, carbon monoxide, oxides of nitrogen, volatile organic compounds, photochemical smog and ozone, particulate matter, oxides of sulphur and lead	2
4.2	Meteorology: adiabatic lapse rate, atmospheric stability, temperature inversions and mixing depths	1
4.3	Smokestack plume and adiabatic lapse rate, point source Gaussian plume model, dispersion coefficients, line source model, area source model	2
4.4	Automobile emissions, emission standard, emission control methods	1
4.5	Stationary emissions, coal fired powerplants, precombustion controls, fluidized bed combustion, IGCC, fluegas scrubbers, cyclone collectors, electrostatic precipitators	2
5	**Solid waste management**	
5.1	Source reduction, material selection, material life extension, process management, efficient distribution	1
5.2	Life cycle assessment	1
5.3	Recycling; paper and paper board recycling, plastic recycling, aluminium and other metal recycling	2
5.4	Composting, waste to energy conversions, landfills	3
5.5	Material recovering fecilities and economics	1

Reference Books

1. G. M. Masters, W P Ela, “Introduction to Environmental Engineering and Science”, Prentice Hall

2. Rao C.S., “Environmental Pollution Control Engineering”, New Age International Publishers

3. Richard O Mines jr, “Environmental Engineering: Principles and Practice”, Wiley

4. D. Nevers, “Air Pollution Control Engineering”, McGraw Hill

221EME019	ENERGY POLICIES FOR SUSTAINABLE DEVELOPMENT	CATEGORY	L	T	P	CREDIT
		PROGRAM ELECTIVE 2	3	0	0	3

Preamble:

The Energy policies for sustainable development are a subject that has a vast scope as well as enormous amount of importance in today's world. The focus of the Energy policies for sustainable development course is to provide an intensive introduction to the basic perspectives, major developments in the environmental policy of the country, environmental regulations associated with energy policy and recent innovations, and implications of emerging national issues and institutions. It also emphasis to develop student's skills in critical thinking and reasoning about policy issues associated with various industrial sectors.

Course Outcomes:

After the completion of the course the student will be able to

CO 1	Understand Indian energy sector, the sustainability issues and the evolution of the policy landscape
CO 2	Evaluate the nature of the policy issues and the interplay of many cross-sectorial aspects in the policy making in the energy sector
CO 3	Apply energy audit for sustainable development
CO 4	Understand the basics of economic analysis for the feasibility study of energy projects
CO 5	Apply tools and techniques needed for policy making in the context of energy sector and sustainable development

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7
CO 1						2	
CO 2						2	
CO 3						2	
CO 4						3	
CO 5						2	

Assessment Pattern

Bloom's Category	End Semester Examination
Apply	25% (roughly)
Analyse	25% (roughly)

Evaluate	50% (roughly)
Create	

Mark distribution

Total Marks	CIE	ESE	ESE Duration
100	40	60	2.5 hours

Continuous Internal Evaluation Pattern:

Preparing a review article based on peer reviewed original publications (minimum 10 publications shall be referred): 15 marks

Course based task/Seminar/Data collection and interpretation: 15 marks

Test paper, 1 no. : 10 marks

Test paper shall include minimum 80% of the syllabus.

End Semester Examination Pattern:

The end semester examination will be conducted by the respective College. There will be two parts; Part A and Part B. Part A will contain 5 numerical/short answer questions with 1 question from each module, having 5 marks for each question (such questions shall be useful in the testing of knowledge, skills, comprehension, application, analysis, synthesis, evaluation and understanding of the students). Students should answer all questions. Part B will contain 7 questions (such questions shall be useful in the testing of overall achievement and maturity of the students in a course, through long answer questions relating to theoretical/practical knowledge, derivations, problem solving and quantitative evaluation), with minimum one question from each module of which student should answer any five. Each question can carry 7 marks.

Note: The marks obtained for the ESE for an elective course shall not exceed 20% over the average ESE mark % for the core courses. ESE marks awarded to a student for each elective course shall be normalized accordingly. For example, if the average end semester mark % for a core course is 40, then the maximum eligible mark % for an elective course is 40+20 = 60 %.

Model Question paper

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY

FIRST SEMESTER M.TECH. DEGREE EXAMINATION

221EME019 – ENERGY POLICIES FOR SUSTAINABLE DEVELOPMENT

Max. Marks: 60 **Duration: 2.5 Hours**

Part A
(Answer *all* questions – each question carries 5 marks)

1) What is the significance of energy security and what are the actions to foster energy security?

2) What is Kyoto Protocol?

3) Suggest an investment criterion for a project which generate substantial cash inflows in earlier years

4) Propose a cost benefit analysis method criterion for the principal government investment project for natural resources.

5) Identify the critical features in Indian energy policy 2020.

(5 x 5 =25 marks)

Part B
(Answer *any* 5 questions – each question carries 7 marks)

6) Discuss how DEFENDUS approach can be used various energy resurces and carriers?

7) What are the common methods for effluent treatment?

8) Explain how CAP & TRADE systems benefits sustainable development?

9) Investment for an energy proposal is Rs.10.00 lakhs. Annual savings for the first three years is 150,000, 200,000 & 300,000. Considering cost of capital as 10%, what is the net present value of the proposal?

10) Calculate the internal rate of return for an economizer that will cost Rs.500,000, will last 10 years, and will result in fuel savings of Rs.150,000 each year.

11) Using NPV criterion decide whether to go ahead with a project

for the data given in the table, where the discount rate is 4%.

Year	0	1	2	3	4	5
Benefit	0	2500	2500	2500	3000	3000
Cost	10,000	500	500	500	500	500
Net	-10,000	2000	2000	2000	2000	2000

12) What are the basic approaches to energy policy analysis?

(5 x 7 =35 marks)

Syllabus

Module	Content	Hours
1	Energy policies of India - Supply focus approach and its limitations - Energy paradigms – Development-focused end-use-oriented service-directed (DEFENDUS) approach - End use orientation – Energy policies and development - Central and State policies on the consumption and wastage of energy – Energy security-Critical analysis - Need for renewable energy.	8
2	Energy and environment - Green house effect – Global warming - Global scenario – Kyoto Protocol , Indian environmental degradation - Environmental laws - Water (prevention & control of pollution) act 1974 - The environmental protection act 1986 – Effluent standards and ambient air quality Standards - Latest development in climate change policies & CDM.	8
3	Energy conservation schemes - Statutory requirements of energy audit - Economic aspects of energy audit - Capital investments in energy saving equipment - Tax rebates - Advantages of 100% depreciation – India‟s plan for a domestic energy cap & trade scheme.	8
4	Social cost benefit analysis - Computation Net present value criterion (NPV) and Internal revenue return (IRR) - Advance models in energy planning – Dynamic programming models in integrated energy planning - Energy planning case studies - Development of energy management systems – Decision support systems for energy planning and energy policy	8

	simulation.	
5	Energy Scenarios and energy vulnerabilities: Scenarios analysis in policy formulation, Indian energy policy 2020, Make in India. Quantitative and qualitative parameters in future associated with the chosen policy options. Policy Tools & Techniques: Tools and methods to address complex Energy policy problems in the context of sustainable development. Assessment of the desirability of a policy option. Different kinds of analysis such as GIS, cost-benefit, social cost benefit, tradeoffs, technology evaluation etc.	8

Course Plan

No	Topic	No. of Lectures
1	**Energy policies of India**	
1.1	Energy policies of India - Supply focus approach and its limitations – India's energy policy 2020. Energy security Electricity Bill 2003 and formation of State and Center Electricity Regulatory Commissions. Electricity generation tariffs arrived at through competitive bidding in renewable energy	3
1.2	Development-focused end-use-oriented service-directed (DEFENDUS) approach - End use orientation – Energy policies and development - Central and State policies on the consumption and wastage of energy - Critical analysis	3
1.3	Need for renewable energy. Availability, current status, major achievements and future potentials of renewable energy options in India	2
2	**Energy and environment**	
2.1	Greenhouse effect – Global warming - Global scenario – Indian environmental degradation, Kyoto Protocol	3
2.2	Challenges for India's clean energy transition, challenges in transport sector, electricity sector. Clean Passenger and Freight Movement. Challenges for a claen ener4gy economy	2
2.3	Environmental laws - Water (prevention & control of pollution) act 1974 - The environmental protection act 1986 – Effluent standards and ambient air quality Standards - Latest development in climate change policies & Clean development mechanism (CDM).	3
3	**Energy conservation schemes**	
3.1	Statutory requirements of energy audit – BEE regulations, Economic aspects of energy audit, data to be collected in auditing-types of audits.	3
3.2	Capital investments in energy saving equipment - Investment appraisal, Simple Payback, Return on Investment (ROI) and Cash Flow, Numerical examples.	3
3.3	Tax rebates - Advantages of 100% depreciation – India"s plan for a domestic energy cap & trade scheme. Cap and trade systems, Energy conservation	2

	amendment bill	
4	**Social cost benefit analysis**	
4.1	Social cost benefit analysis for natural resurces- Net present value criterian (NPV) and Internal revenue return (IRR). - Examples	3
4.2	Advance models in energy planning – Dynamic programming models in integrated energy planning - Energy planning case studies	3
4.3	Development of energy management systems – Decision support systems for energy planning and energy policy simulation.	2
5	**Energy Scenarios and energy vulnerabilities**	
5.1	Scenarios analysis in policy formulation, building futuristic and long-term scenarios with modelling techniques, Indian energy policy 2020. Energy policy and make in India.	3
5.2	Quantitative and qualitative parameters in future associated with the chosen policy options. Tools and methods to address complex Energy policy problems in the context of sustainable development	2
5.3	Assessment of the desirability of a policy option. Different kinds of analysis such as GIS, cost-benefit, social cost benefit, trade-offs, technology evaluation etc	3

Reference Books

1. J. Goldemberg, T. B. Johansson, A.K.N. Reddy and R.H. Williams: Energy for a Sustainable World, Wiley Eastern, 1990
2. P. Chandra: Financial Management Theory and Practice, Tata McGraw Hill, 1992.
3. Annual Energy Planning Reports of CMIE, Govt. of India.
4. A.K.N. Reddy and A.S. Bhalla: The Technological Transformation of Rural Inda, UN Publications, 1997
5. A.K.N. Reddy, R.H. Williams and J.B. Johanson: Energy After Rio-Prospects and Challenges, UN Publications, 1997
6. P. Meier and M. Munasinghe: Energy Policy Analysis & Modeling, Cambridge University Press, 1993
7. R.S. Pindyck and D.L. Rubinfeld: Economic Models and Energy Forecasts, 4e, McGraw Hill, 1998

221EME020	WIND TURBINE TECHNOLOGIES	CATEGORY	L	T	P	CREDIT
		PROGRAM ELECTIVE 2	3	0	0	3

Preamble:

Wind energy has grown to be a main source of energy in many parts of the world. It is clean, fuel free and cost effective. Wind energy is a massive indigenous power source which is permanently available in almost all countries. Wind energy technology grows in various stages nationally and internationally. This course introduces important advances in wind turbine technologies.

Course Outcomes:

After the completion of the course the student will be able to

CO 1	Understand the importance and feasibility of wind energy
CO 2	Understand fundamental principles involved in aerofoil theory related to turbine blades.
CO 3	Design blades for wind turbines.
CO 4	Understand methods for controlling wind turbines.
CO 5	Design financially viable wind turbine projects

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7
CO 1	1	1		2	1	2	3
CO 2	3	2	2	2	2		
CO 3	3		2	3	3	3	2
CO 4	3			2	2	2	1
CO 5		3					3

Assessment Pattern

Bloom's Category	End Semester Examination (%)
Apply	30
Analyse	30
Evaluate	30
Create	10

Mark distribution

Total Marks	CIE	ESE	ESE Duration
100	40	60	2.5 hours

Continuous Internal Evaluation Pattern: 40 marks

Preparing a review article based on peer reviewed original publications (minimum 10 publications shall be referred)	:	15 marks
Course based task/Seminar/Data collection an interpretation	:	15 marks
Test paper, 1 no.	:	10 marks

Test paper shall include minimum 80% of the syllabus. Evaluation shall only be based on application, analysis or design-based questions.

End Semester Examination Pattern:

The end semester examination will be conducted by the respective College. There will be two parts; Part A and Part B. Part A will contain 5 numerical/short answer questions with 1 question from each module, having 5 marks for each question (such questions shall be useful in the testing of knowledge, skills, comprehension, application, analysis, synthesis, evaluation and understanding of the students). Students should answer all questions. Part B will contain 7 questions (such questions shall be useful in the testing of overall achievement and maturity of the students in a course, through long answer questions relating to theoretical/practical knowledge, derivations, problem solving and quantitative evaluation), with minimum one question from each module of which student should answer any five. Each question can carry 7 marks.

Note: The marks obtained for the ESE for an elective course shall not exceed 20% over the average ESE mark % for the core courses. ESE marks awarded to a student for each elective course shall be normalized accordingly. For example, if the average end semester mark % for a core course is 40, then the maximum eligible mark % for an elective course is 40+20 = 60 %.

Model Question Paper

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY

FIRST SEMESTER M.TECH. DEGREE EXAMINATION

221EME020 – WIND TURBINE TECHNOLOGIES

Max. Marks: 60 **Duration: 2.5 Hours**

PART A

Answer all questions

Each question carries 5 marks

1. Compare Vertical and Horizontal axis wind turbines.
2. Illustrate the translating aero foil with lift and Drag forces acting on it.
3. What are the different loads to be considered for designing the ultimate load of the turbine?
4. What are the three main parameters that have to be considered when a turbine must be connected to a grid?
5. What are the major environmental concerns for the off shore wind farm?

4 x 5 marks = 20 marks

PART B

Answer Any Five Questions

6. How the wind data monitoring, recording and analyzing is performed? How the variations of velocity and directions are represented graphically?
7. What is Betz criterion? Derive an expression for the same using Momentum theory.
8. A 60m diameter rotor experiences an undisturbed wind speed of 10m/s. If it is operating at maximum Cp, Calculate: (a) Pressure difference across the disc. (b) Thrust on the rotor. (c) Maximum possible thrust on the rotor. (d) Maximum power developed by the rotor.
9. List all the design tasks involved in the design of a modern wind turbine.
10. What are the parameters associated with wind turbine control. Explain blade pitch control and yaw control.
11. Calculate the cost of energy for a 50kW wind turbine which has the capacity to produces120000 kWh/year. The installed cost is Rs 90,00,000/-, fixed charge rate is 10 percent, Operation and Maintenance

cost is one percent of installed cost and levelized replacement cost is Rs 2,40,000/-.

12. Explain the following

(a) Renewable Energy portfolio standard (b) Capital Recovery factor.

5X7 Marks = 35 Marks

Syllabus

Module -1

Introduction to wind power: wind power scenario in India-Benefits and disadvantages of wind power, Wind Resource Assessment-Characteristics of steady wind, Weibull wind speed Distribution Function, Wind Rose-Energy pattern factor- Energy content of the wind. Resource Assessment: Measurement Plan-Monitoring Duration-Siting of Monitoring Systems-Site-Specific Wind Data, Topographic Indicators-Field surveys-Tower Placement-Measurement Parameters-Remote wind speed sensing Techniques. Wind turbine classification: HAWT-VAWT-propeller wind turbine-H rotor. Propeller wind turbine and its components.

Module-2

Two - dimensional Aerofoil Theory, Actuator Disc-Axial Momentum Theory-Betz law-Momentum Theory for a Rotating Wake, Blade Element Theory-Strip Theory, Tip Losses-Tip loss correction-Wind Machine Parameters-Cp-λ Characteristics, SERI Blade sections, Wind Machine Mechanics-Fixed Speed and variable speed machines-Load Matching.

Module-3

Rotor Blade Theory: Blade Element – Momentum Theory, Rotor Torque and Power, Glauert Momentum Vortex Theory, Optimal rotors-Blade geometry, Variation of Aerofoil Characteristics with Reynolds number-Cambered aerofoils, Blade loads-Rotor Loads-Basis for Design load. Forms of Blade structure-Blade Materials-Rotor Hub, Non-destructive testing for wind turbine blades.

Module-4

Control of wind turbines (Mechanical) – Parameters, Power calculations-output power quality and requirement, Blade pitch control, Turbine operating power curve—yaw control-parking brake. Control of wind turbines (Electrical) - DC generators-synchronous generators. Modes of operation of wind turbines-direct drive mode-Fixed speed mode- variable speed mode-Squirrel-cage generator mode-variable slip mode.

Module-5

Wind Energy Economics: Cost Calculation - Annual Energy Output, Simple Payback Period - Capital Recovery Factor, Deprecation - Life Cycle costing, Project Appraisal. Environmental Impact: Biological Impact-Visual Impact-Shadow Flicker, Sound Impact-Measurement-Prediction and Assessment-Communication Impact

Course Plan

No	Topic	No. of Lectures
1	**Module -1**	
1.1	Introduction to wind power: wind power scenario in India-Benefits and disadvantages of wind power	1
1.2	Wind Resource Assessment-Characteristics of steady wind	1
1.3	Weibull wind speed Distribution Function	1
1.4	Wind Rose-Energy pattern factor- Energy content of the wind.	1
1.5	Resource Assessment: Measurement Plan-Monitoring Duration-Siting of Monitoring Systems-Site-Specific Wind Data	1
1.6	Topographic Indicators-Field surveys-Tower Placement-Measurement Parameters-Remote wind speed sensing Techniques.	1
1.7	Wind turbine classification: HAWT-VAWT-propeller wind turbine-H rotor.	1
1.8	Propeller wind turbine and its components.	2
2	**Module-2**	
2.1	Two - dimensional Aerofoil Theory	1
2.2	Actuator Disc-Axial Momentum Theory-Betz law-Momentum Theory for a Rotating Wake	2
2.3	Blade Element Theory-Strip Theory	1
2.4	Tip Losses-Tip loss correction-Wind Machine Parameters-Cp-λ Characteristics	2
2.6	SERI Blade sections	1
2.7	Wind Machine Mechanics-Fixed Speed and variable speed machines-Load Matching.	2
3	**Module-3**	
3.1	Rotor Blade Theory: Blade Element – Momentum Theory	2
3.2	Rotor Torque and Power	2
3.3	Glauert Momentum Vortex Theory	1
3.4	Optimal rotors-Blade geometry	1

3.5	Variation of Aerofoil Characteristics with Reynolds number-Cambered aerofoils	2
3.6	Blade loads-Rotor Loads-Basis for Design load.	2
3.7	Forms of Blade structure-Blade Materials-Rotor Hub.	2
3.8	Non-destructive testing for wind turbine blades	1
4	**Module 4**	
4.1	Control of wind turbines (Mechanical) - Parameters.	1
4.2	Power calculations-output power quality and requirement	2
4.3	Blade pitch control	1
4.4	Turbine operating power curve—yaw control-parking brake.	1
4.5	Control of wind turbines (Electrical) - DC generators-synchronous generators	1
4.6	Induction generators-Doubly feed Induction generator-	1
4.7	Modes of operation of wind turbines-direct drive mode-Fixed speed mode- variable speed mode-Squirrel-cage generator mode-variable slip mode.	3
5	**Module 5**	
5.1	Wind Energy Economics: Cost Calculation - Annual Energy Output	1
5.2	Simple Payback Period - Capital Recovery Factor	1
5.3	Deprecation - Life Cycle costing	1
5.4	Project Appraisal.	2
5.5	Environmental Impact: Biological Impact-Visual Impact-Shadow Flicker.	2
5.6	Sound Impact-Measurement-Prediction and Assessment-Communication Impact	1

Text Books:

1. Wind Energy Theory and Practice: Siraj Ahmed, PHI Learning Private Limited, New Delhi.

References:

1. Wind Power plants and Project Development, Joshua and Tore, PHL Learning Pvt Ltd, 2011.

2. Wind Turbine Technology, A R Jha, CRC Press 2017.

3. James F. Manwell, Jon G. McGowan, Anthony L. Rogers, Wind Energy Explained: Theory, Design and Application, 2nd Edition, John Wiley & Sons, Ltd., 2010.

4. Vaughn Nelson, Wind Energy: Renewable Energy and the Environment, Second Edition, CRC Press, 2013.

221EME021	POWER ELECTRONICS FOR ENERGY SYSTEMS	CATEGORY	L	T	P	CREDIT
		PROGRAM ELECTIVE 2	3	0	0	3

Preamble:

This course introduces the knowledge about the power semiconductor devices and various power converters for renewable energy systems.

Course Outcomes:

After the completion of the course the student will be able to

CO 1	Acquire knowledge about the concepts and techniques used in power electronics circuits.
CO 2	Analyse the working of controlled rectifiers and dc-dc converters
CO 3	Explain the working of ac voltage controllers, inverters and PWM techniques
CO 4	Understand the application of power electronic converters in renewable energy systems.

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7
CO 1	3	2		2			
CO 2	3	2		2			
CO 3	3	2		2			
CO 4	3	2		2		1	1

Assessment Pattern

Bloom's Category	End Semester Examination (%)
Apply	20
Analyse	20
Evaluate	10
Create	10

Mark distribution

Total Marks	CIE	ESE	ESE Duration
100	40	60	2.5 hours

Continuous Internal Evaluation Pattern:

Preparing a review article based on peer reviewed original publications (minimum 10 publications shall be referred): 15 marks

Course based task/Seminar/Data collection and interpretation: 15 marks

Test paper, 1 no. : 10 marks

Test paper shall include minimum 80% of the syllabus.

End Semester Examination Pattern:

The end semester examination will be conducted by the respective College. There will be two parts; Part A and Part B. Part A will contain 5 numerical/short answer questions with 1 question from each module, having 5 marks for each question (such questions shall be useful in the testing of knowledge, skills, comprehension, application, analysis, synthesis, evaluation and understanding of the students). Students should answer all questions. Part B will contain 7 questions (such questions shall be useful in the testing of overall achievement and maturity of the students in a course, through long answer questions relating to theoretical/practical knowledge, derivations, problem solving and quantitative evaluation), with minimum one question from each module of which student should answer any five. Each question can carry 7 marks.

Note: The marks obtained for the ESE for an elective course shall not exceed 20% over the average ESE mark % for the core courses. ESE marks awarded to a student for each elective course shall be normalized accordingly.

Model Question Paper

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY

FIRST SEMESTER M.TECH. DEGREE EXAMINATION

221EME021 – POWER ELECTRONICS FOR ENERGY SYSTEMS

Max. Marks: 60 **Duration: 2.5 Hours**

PART A

Answer all questions

Each question carries 5 marks

1. Sketch the output characteristics of a Power BJT and explain the regions in which it acts as a switch.
2. Discuss freewheeling effect in controlled rectifiers.
3. Discuss principle of operation of type A chopper.
4. Draw different types of three phase AC voltage controller configurations.
5. Explain the types of solar PV systems.

Part B

Answer any five questions

Each question carries 7 marks

6. With a neat figure, explain the structure of an IGBT together with its switching characteristics.
7. A single phase fully controlled bridge rectifier is feeding an RL load. Draw and explain the working of the circuit with relevant waveforms. Derive average and RMS values of the output voltage. Consider the firing angle of 30° and a continuous conduction load current.
8. For a thyristor controlled step up chopper the DC input voltage is 220V. The duty ratio is 0.6 and the chopping frequency is 1kHz. Determine the value of the output voltage, width of the output voltage pulse and the conducting time of the thyristor.
9. Explain the four-quadrant operation of a dc chopper.

10. Explain the operation of single-phase ac voltage controllers.

11. Explain with circuit diagram and waveforms, the operation of athree-phase inverter with 120° conduction mode.

12. With a neat block diagram, explain the operation of wind energy conversion systems.

Syllabus

Module 1 – 7 hrs

Power Semiconductor devices: Ideal and Real switches, Power Diodes, Thyristors, Power BJTs, Power MOSFETs, IGBTs - Static and Dynamic Performance, Driver circuits for Power MOSFET and IGBT. Introduction to Wideband gap semi-conductor devices.

Module 2 – 9 hrs

Controlled Rectifier - Half wave-controlled rectifier with R Load and RL load. Fully controlled and half controlled bridge rectifier with R, RL and RLE loads (Continuous and discontinuous conduction – Analysis not required))
Three phase controlled Rectifiers with R and RLE Loads, RL and RLE Loads with Free Wheeling Diode (Analysis not required).

Module 3 – 8 hrs

DC Choppers – Principle of operation - Single quadrant, two quadrant and four quadrant choppers.
DC - DC Converters: Design and operation of Buck, Boost and Buck-Boost converters (Continuous conduction mode only)

Module 4 – 8 hrs

AC Voltage Controllers: Single Phase and Three Phase AC Voltage Controllers - Principle of operation with R and RL Load. (Analysis not required).
Single phase inverters – Half bridge and full bridge. – Sine PWM inverters.
Three phase Inverters – 180 ° and 120 ° mode of operation.

Module 5 – 8 hrs

Solar Photovoltaic System: Block diagram of PV system, MPPT (P&O algorithm), selection of inverter, battery and inverter sizing, Operation of stand-alone and grid connected PV systems.
Wind Energy Conversion systems: Principle of wind energy conversion systems, types of wind mills, Grid connected wind energy systems.
Introduction to solar - wind Hybrid Systems: Need for Hybrid Systems

Course Plan

No	Topic	No. of Lectures
1	**Power Semiconductor devices**	
1.1	Ideal and Real switches, Power Diodes, Thyristors - Static and Dynamic Performance	2
1.2	Power BJTs, Power MOSFETs, IGBTs - Static and Dynamic Performance	2
1.3	Driver circuits for Power MOSFET and IGBT	2
1.4	Introduction to Wideband gap semi-conductor devices.	1
2	**Controlled Rectifiers and DC - DC Converters**	
2.1	**Controlled Rectifiers** - Half wave controlled rectifier with R Load and RL load	3
2.2	Fully controlled and half controlled bridge rectifier with R, RL and RLE loads (Continuous and discontinuous conduction)	3
2.3	**Three phase controlled Rectifiers** with R and RLE Loads, RL and RLE Loads with Free Wheeling Diode (Analysis not required).	3
3	**DC - DC Converters**	
3.1	**DC Choppers –** Principle of operation - Single quadrant, two quadrant and four quadrant chopper	2
3.2	**DC - DC Converters for energy systems:** Design and operation of Buck, Boost converters	3
3.3	Design and operation of Buck-Boost converters (Continuous conduction mode only)	3
4	**AC Voltage Controllers and Inverters**	
4.1	**AC Voltage Controllers:** Single Phase and Three Phase AC Voltage Controllers - Principle of operation with R and RL Load.	2
4.2	**Single phase inverters** Half bridge and full bridge. – Sine PWM inverters.	2
4.3	**Three phase Inverters** - 3-phase bridge inverter with R load – 120° and 180° conduction modes	2
4.4	PWM Techniques (Sine PWM only - with unipolar and bipolar PWM)	2
5	**Solar and wind energy systems**	
5.1	**Solar Photovoltaic System**: Block diagram of PV system, batteries-charge controls, MPPT (P&O algorithm), selection of inverter, battery sizing, array sizing, Block diagram for grid connected PV systems.	3
5.2	**Wind Energy Conversion systems:** Block Diagram of stand-alone and Grid connected wind energy	3

	systems.	
5.3	**Introduction to solar - wind Hybrid Systems :** Need for Hybrid Systems and Block Diagram	2

Reference Books

1. Ned Mohan, Underland, Robbins, " *Power Electronics, Converters, Applications and Design* ", 3rd Edition, John Wiley & Sons, Inc. , 2006
2. Dr. PS Bimbhra, " *Power Elecrronics* ", Khanna Publishers
3. Muhammed H. Rasheed, " *Alternative Energy in Power Electronics*", Elsevier Inc., 2015
4. L. Umanand, " *Power Electronics - Essentials and Applications* ", Wiley India Pvt.Ltd., 2009
5. D.P. Kothari, KC Singal, Rakesh Rajan, "Renewable Energy Sources and Emerging Technologies", PHI Learning Pvt.Ltd., 2013

221EME022	SOLAR ENERGY SYSTEMS	CATEGORY	L	T	P	CREDIT
		PROGRAM ELECTIVE 2	3	0	0	3

Preamble:

This course provides an in-depth knowledge about the working of various solar thermal systems and photovoltaic systems with an emphasis on their technology and applications

Course Outcomes:

After the completion of the course the student will be able to

CO 1	Analyse the performance of various solar thermal collectors.
CO 2	Comprehend the concepts of various solar thermal energy conversion systems
CO 3	Design solar photovoltaic energy conversion and transmission systems.
CO 4	Discuss the utilization of solar energy for thermal comfort.

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7
CO 1	3	-	2	3	-	3	-
CO 2	3	-	2	3	-	3	-
CO 3	3	-	2	3	-	3	-
CO 4	3	-	2	3	-	3	-

Assessment Pattern

Bloom's Category	End Semester Examination (%)
Apply	20
Analyse	20
Evaluate	10
Create	10

Mark distribution

Total Marks	CIE	ESE	ESE Duration
100	40	60	2.5 hours

Continuous Internal Evaluation Pattern:

Preparing a review article based on peer reviewed original publications (minimum 10 publications shall be referred): 15 marks

Course based task/Seminar/Data collection and interpretation: 15 marks

Test paper, 1 no. : 10 marks

Test paper shall include minimum 80% of the syllabus.

End Semester Examination Pattern:

The end semester examination will be conducted by the respective College. There will be two parts; Part A and Part B. Part A will contain 5 numerical/short answer questions with 1 question from each module, having 5 marks for each question (such questions shall be useful in the testing of knowledge, skills, comprehension, application, analysis, synthesis, evaluation and understanding of the students). Students should answer all questions. Part B will contain 7 questions (such questions shall be useful in the testing of overall achievement and maturity of the students in a course, through long answer questions relating to theoretical/practical knowledge, derivations, problem solving and quantitative evaluation), with minimum one question from each module of which student should answer any five. Each question can carry 7 marks.

Note: The marks obtained for the ESE for an elective course shall not exceed 20% over the average ESE mark % for the core courses. ESE marks awarded to a student for each elective course shall be normalized accordingly.

Model Question Paper

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY

FIRST SEMESTER M.TECH. DEGREE EXAMINATION

221EME022 – SOLAR ENERGY SYSTEMS

Max. Marks: 60 **Duration: 2.5 Hours**

PART A

Answer all questions

Each question carries 5 marks

1. What is the function of pyranometer? How a pyranometer can be modified to be used to measure diffuse radiation?
2. With a neat sketch, explain the working of a central receiver solar power plant.
3. Is photo voltaic conversion governed by Carnot efficiency? Justify. What is the limitation in the theoretical maximum efficiency of Silicon solar cell?
4. Explain, with the help of graphical representation, the effect of series and parallel connection of PV cells in a module on the voltage, current and power generated by the module.
5. Describe the basic components of passive space heating system.

PART B

Answer any five questions

Each question carries 7 marks

6. With the help of a diagram, explain the components of solar thermal (liquid type) flat plate collectors.
7. Explain the different classes of heat transfer fluids used in various solar thermal and cooling applications.
8. What is meant by doping of semiconductors? Explain, with examples, how n-doping and p-doping make a semiconductor material into an easily conducting materials.

9. a) What are the reasons for efficiency losses in a solar PV cell?

(5 Marks)

b) What are the effects of difference in short circuit currents produced by two PV cells on the voltage, current and power when they are connected in series?

(2 Marks)

10. What are the different energy losses in a cell?

11. Explain the different aspects of day lighting application inside buildings.

12. Explain with necessary calculation, the theory of earth contact cooling.

Syllabus

Module	Content	Hours
1	Instruments for solar radiation measurements. Flat plate collector thermal analysis - testing methods, evacuated tubular collectors –Sun tracking concentrating collectors: classification, design and performance parameters, tracking systems, compound parabolic concentrators, parabolic trough concentrators, concentrators with point focus, Fresnel collectors, Heliostats.	8
2	Heat transfer fluids for solar collectors, Emerging technologies in solar concentrators, Solar thermal power generation schemes: Central receiver power plants (solar power towers) - solar chimney power plants - Dish sterling systems - solar ponds - thermal analysis of solar power plants.	7
3	Semiconductor – properties - energy levels - basic equations of semiconductor devices physics. Solar cells - p-n junction: homo and heterojunctions - metal-semiconductor interface -characteristics - the figure of merits of solar cell - efficiency limits - a variation of efficiency with band-gap and temperature - efficiency measurements - high-efficiency cells – Solar thermo-photovoltaics.	8
4	Solar cell array system analysis and performance prediction, Shadow analysis: reliability - solar cell array design concepts - PV system design - design process and optimization - detailed array design - storage autonomy - maximum tracking - centralized and decentralized SPV	8

	systems - standalone - hybrid and grid-connected system	
5	Power electric circuits for output of solar panels: Choppers, inverters, batteries, charge regulators. Thermal comfort - bioclimatic classification – passive heating concepts: direct heat gain - indirect heat gain - isolated gain and sunspaces - passive cooling concepts: evaporative cooling - Radiative cooling - application of wind, water and earth for cooling; shading - paints and cavity walls for cooling - roof radiation traps - earth air-tunnel. – energy-efficient landscape design - thermal comfort	9

Course Plan

No	Topic	No. of Lectures
1	**MODULE 1**	**8**
1.1	Instruments for solar radiation measurements.	2
1.2	Flat plate collector thermal analysis - testing methods, evacuated tubular collectors	2
1.3	Sun tracking concentrating collectors: classification, design and performance parameters, tracking systems	2
1.4	compound parabolic concentrators, parabolic trough concentrators, concentrators with point focus, Fresnel collectors, Heliostats.	2
2	**MODULE 2**	**7**
2.1	Heat transfer fluids for solar collectors, Emerging technologies in solar concentrators	2
2.2	Solar thermal power generation schemes: Central receiver power plants (solar power towers) - solar chimney power plants, Dish sterling systems	3
2.3	Solar ponds, thermal analysis of solar power plants.	2
3	**MODULE 3**	**8**
3.1	Semiconductor – properties - energy levels - basic equations of semiconductor devices physics	2
3.2	Solar cells - p-n junction: homo and heterojunctions - metal-semiconductor interface -characteristics	2
3.3	The figure of merits of solar cell - efficiency limits - variation of efficiency with band-gap and temperature	2
3.4	Efficiency measurements - high-efficiency cells – Solar thermo-photovoltaics.	2
4	**MODULE 4**	**8**
4.1	Solar cell array system analysis and performance prediction	1
4.2	Shadow analysis: reliability - solar cell array design concepts	2
4.3	PV system design - design process and optimization - detailed array design	2
4.4	Storage autonomy - maximum tracking - centralized and decentralized SPV systems -	2
4.5	Standalone -hybrid and grid-connected system.	1
5	**MODULE 5**	**9**
5.1	Power electric circuits for output of solar panels:	2

	Choppers, inverters, batteries, charge regulators.	
5.2	Thermal comfort - bioclimatic classification – passive heating concepts	1
5.3	Direct heat gain - indirect heat gain - isolated gain and sunspaces	1
5.4	Passive cooling concepts: evaporative cooling - Radiative cooling - application of wind, water and earth for cooling	2
5.5	Shading - paints and cavity walls for cooling - roof radiation traps - earth air-tunnel	2
5.6	Energy-efficient landscape design - thermal comfort.	1

Reference Books

1. Goswami D.Y., Kreider, J. F., Francis., Principles of Solar Engineering, 3rd Edition, CRC Press, 2015.
2. Chetan Singh Solanki, Solar Photovoltaics – Fundamentals, Technologies and Applications, PHI Learning Private Limited.
3. Sukhatme S.P., Nayak. J.P., Solar Energy – Principle of Thermal Collection and Storage, Tata McGraw Hill, 2008.
4. Roger A. Messenger, Amir Abtahi, Photovoltaic Systems Engineering,4th Edition, CRC Press, 2017
5. Garg H. P. and Prakash J., Solar Energy – Fundamentals and Applications, Tata McGraw Hill, 2016

221EME023	ENERGY STORAGE TECHNOLOGIES	CATEGORY	L	T	P	CREDIT
		PROGRAM ELECTIVE 2	3	0	0	3

Preamble: Nil

Course Outcomes:

After the completion of the course the student will be able to

CO 1	Describe the various Chemical and Thermal Energy storage systems.
CO 2	Apply the principles of Electro-Chemical Batteries to design effective storage systems
CO 3	Describe the use of special materials for effective energy storage systems.
CO 4	Select appropriate energy storage systems based on technical and economic considerations.

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7
CO 1	3	-	2	2	-	-	-
CO 2	3	-	2	2	-	-	-
CO 3	3	-	2	2	-	-	-
CO 4	3	-	2	2	-	-	-

Assessment Pattern

Bloom's Category	End Semester Examination (%)
Apply	30
Analyse	30
Evaluate	30
Create	10

Mark distribution

Total Marks	CIE	ESE	ESE Duration
100	40	60	2.5 hours

Continuous Internal Evaluation Pattern:

Preparing a review article based on peer reviewed original publications (minimum 10 publications shall be referred): 15 marks

Course based task/Seminar/Data collection and interpretation: 15 marks

Test paper, 1 no. : 10 marks

Test paper shall include minimum 80% of the syllabus.

End Semester Examination Pattern:

The end semester examination will be conducted by the respective College. There will be two parts; Part A and Part B. Part A will contain 5 numerical/short answer questions with 1 question from each module, having 5 marks for each question (such questions shall be useful in the testing of knowledge, skills, comprehension, application, analysis, synthesis, evaluation and understanding of the students). Students should answer all questions. Part B will contain 7 questions (such questions shall be useful in the testing of overall achievement and maturity of the students in a course, through long answer questions relating to theoretical/practical knowledge, derivations, problem solving and quantitative evaluation), with minimum one question from each module of which student should answer any five. Each question can carry 7 marks.
Note: The marks obtained for the ESE for an elective course shall not exceed 20% over the average ESE mark % for the core courses. ESE marks awarded to a student for each elective course shall be normalized accordingly. For example, if the average end semester mark % for a core course is 40, then the maximum eligible mark % for an elective course is 40+20 = 60 %.

Model Question Paper

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY

FIRST SEMESTER M.TECH. DEGREE EXAMINATION

221EME023 – ENERGY STORAGE TECHNOLOGIES

Max. Marks: 60 **Duration: 2.5 Hours**

PART A

Answer all questions

Each question carries 5 marks

1. Explain the major hazards associated with LNG storage facilities.
2. With a neat sketch, explain a pressurised water energy storage system.
3. Explain primary and secondary batteries. Describe the working of Lead-Acid batteries.
4. Explain the advantages and disadvantages of PCM over conventional water storage techniques for thermal energy storage.
5. With a schematic, explain the concept of a hybrid energy storage system. What are its advantages?

PART B

Answer any five questions

Each question carries 7 marks

6. What are the general considerations of LNG and hydrogen storage systems? With the help of a schematic diagram, explain a hydrogen storage system.
7. a) According to the thermal mechanism used to store energy, how thermal energy storage systems are classified? Explain in detail.

   b) With a neat sketch explain the working of a rock bed thermal energy storage system

8. What is a solar pond? With necessary sketches, explain the working of non-convecting and convecting solar ponds.

9. Draw the schematic diagram of a supercapacitor and describe its working principle. Classify supercapacitors according to the energy storage mechanisms of the electrode materials and the electrolytes used.

10. With a schematic diagram, explain the working of a compressed air energy storage system. Describe the advantages and disadvantages of compressed air energy storage system.

11. Explain the working of

    a) Zinc-Air battery b) Nickel – Metal hydride battery

12. a) Explain the applications of flywheel and supercapacitors.

    b) With a neat sketch, explain the working of a hybrid electric vehicle.

Syllabus

Module	Content	Hours
1	The necessity of energy storage – types of energy storage – comparison of energy storage technologies – Applications. General consideration, petroleum product storages, LPG storages, LNG storages, hydrogen storages, toxic storages, chlorine storages, ammonia storages, other chemical storages – underground storages–loading and unloading facilities–drum and cylinder storage –warehouse, storage hazard assessment of LPG and LNG	8
2	Thermal storage – Types – Modelling of thermal storage units –Simple water and rock bed storage system – pressurized water storage system – Modelling of phase change storage system –Simple units, packed bed storage units -Modelling using the porous medium approach.	7
3	The fundamental concept of batteries – measuring of battery performance, charging and discharging of a battery, storage density, energy density, Free energy, theoretical cell voltage, specific capacity, specific energy, energy density, memory effect, cycle life, shelf life, state of charge (SOC) and depth of discharge (DOD), internal resistance and Coloumbic efficiency and safety issues. Types of batteries – Primary and secondary batteries -Lead Acid, Nickel – Cadmium, Zinc Manganese dioxide and modern batteries for example (i) zinc-Air (ii) Nickel Hydride, (iii) Lithium Battery	7
4	Phase Change Materials, Pumped storage Energy Storage - Sensible, latent heat and thermo-chemical storage-pebble bed etc. materials for phase change-Glauber's salt-organic compounds. Solar ponds	6
5	Flywheel, Supercapacitors, Principles & Methods – Applications, Compressed air Energy storage, Concept of Hybrid Storage –Applications- Combustion Engine Hybrid Electric Vehicles, Laboratory Test of Electric Vehicle Batteries, Vehicle tests with Electric Vehicle Batteries, Future of Electric Vehicles.	7

Course Plan

No	Topic	No. of Lectures
1	**MODULE 1**	**8**
1.1	The necessity of energy storage – types of energy storage – comparison of energy storage technologies – Applications	2
1.2	General consideration of energy storage, petroleum product storages, LPG storages, LNG storages	2
1.3	Hydrogen storages, toxic storages, chlorine storages, ammonia storages, other chemical storages – underground storages.	2
1.4	Underground storages, loading and unloading facilities, drum and cylinder storage	1
1.5	Warehouse, storage hazard assessment of LPG and LNG	1
2	**MODULE 2**	**7**
2.1	Thermal storage – Types	1
2.2	Modelling of thermal storage units	1
2.3	Simple water and rock bed storage system – pressurized water storage system	2
2.4	Modelling of phase change storage system –Simple units	1
2.5	Packed bed storage units -Modelling using the porous medium approach.	2
3	**MODULE 3**	**7**
3.1	The fundamental concept of batteries	1
3.2	measuring of battery performance, charging and discharging of a battery, storage density, energy density, free energy, theoretical cell voltage, specific capacity, specific energy, energy density, memory effect, cycle life, shelf life, state of charge (SOC) and depth of discharge (DOD), internal resistance and Coloumbic efficiency and safety issues	3
3.3	Types of batteries – Primary and secondary batteries, Lead- Acid, Nickel – Cadmium, Zinc- Manganese dioxide and modern batteries for example (i) zinc-Air (ii) Nickel Hydride, (iii) Lithium Battery	3
4	**MODULE 4**	**6**

4.1	Phase Change Materials	1
4.2	Pumped storage Energy Storage - Sensible, latent heat and thermo-chemical storage	2
4.3	Pebble bed etc. materials for phase change-Glauber's salt-organic compounds. Solar ponds	3
5	**MODULE 5**	**7**
5.1	Flywheel, Supercapacitors, Principles & Methods – Applications	2
5.2	Compressed air Energy storage, Concept of Hybrid Storage– Applications-	2
5.3	Combustion Engine Hybrid Electric Vehicles	1
5.4	Laboratory Test of Electric Vehicle Batteries, Vehicle tests with Electric Vehicle Batteries, Future of Electric Vehicles	2

Reference Books

1. Ibrahim Dincer and Mark A. Rosen, Thermal Energy Storage Systems and Applications, John Wiley & Sons 2002.
2. S. P. Sukhatme, Solar Energy - Principles of thermal collection and storage, second edition, Tata McGraw-Hil, New Delhi, 1996.
3. Schmidt F.W and Willmott. A. J., Thermal Storage and Regeneration, Hemisphere Publishing Corporation, 1981
4. Alfred Rufer, Energy Storage Systems and components, CRC Press, 2017
5. Ru-shiliu, Leizhang and Xueliang sun, Electrochemical technologies for energy storage and conversion, Wiley publications, 2012.
6. Power Sources for Electric Vehicles, Edited by B.D. Mc Nicol and D.A.J. Rand, Elsevier Publications,1998
7. Lithium Batteries for Hybrid Cars By John Voelcker, IEEE Spectrum, 1990.
8. Hand Book of Batteries and Fuel cells, 3rd Edition, Edited by David Linden and Thomas.B. Reddy, McGraw Hill Book Company, N.Y. 2002.

221LME001	ENERGY SYSTEMS LABORATORY	CATEGORY	L	T	P	CREDITS
		LABORATORY	0	0	2	1

Course Outcomes

On successful completion of the course, the student will be able to

1. Discuss the functions and operations of various components in energy systems.
2. Illustrate parametric setting for the experimentation in various types of Energy systems.
3. Use the knowledge gained in outcome 2 to conduct experiments and to generate data with a satisfactory level of confidence, within the constraints of precision and accuracy of the measurement devices.
4. Rate the performance of different energy systems by analysing the data based on theoretical knowledge.

List of Experiments

Study and complete any ten experiments from/within the following list.

1. Experimental study of the performance of solar water heaters.
2. Power factor improvement using capacitors
3. Characteristics study of solar photovoltaic devices.
4. Performance study of the biogas plant.
5. Fuel characterization study in different fuels (proximate analysis, calorific value, viscosity, specific gravity etc.,)
6. Measurements of direct and diffused solar radiation.
7. Performance study on the boiler.
8. Performance characteristics of the motor test rig.
9. Computation of pump & pumping system characteristics (pump curve, system curve and BEP).
10. Performance study of vapour compression air conditioning system for different psychrometric operations.
11. Performance study of heat pump.
12. Experimental analysis of the performance of any biomass gasifier.
13. Study of performance, combustion and emission characteristics of VCR engine (Computerised mode).
14. Study of Biodiesel preparation from any plant oil/animal fat.
15. Performance analyses of advanced biomass cook stoves.
16. Testing the Heat Balance of IC Engines.
17. Calculation of overall heat transfer coefficient for parallel/counter flow heat exchanger.
18. Estimation of efficiency of solar flat plate collectors.
19. Effect of shading on module output power.
20. Effect of variation of tilt angle in PV module.
21. Testing of solar still.
22. Study of performance evaluation of PEM/PAFC/MCFC/SOFC Fuel cell.