EE6801 ELECTRIC ENERGY GENERATION, UTILIZATION AND CONSERVATION

LT P C
3 0 0 3

OBJECTIVES:

- To analyze the various concepts behind renewable energy resources.
- To introduce the energy saving concept by different ways of illumination.
- To understand the different methods of electric heating and electric welding.
- To introduce knowledge on Solar Radiation and Solar Energy Collectors
- To introduce concepts of Wind Energy and its utilization

UNIT I ELECTRIC DRIVES AND TRACTION 9

Fundamentals of electric drive - choice of an electric motor - application of motors for particular services - traction motors - characteristic features of traction motor - systems of railway electrification - electric braking - train movement and energy consumption - traction motor control - track equipment and collection gear.

UNIT II ILLUMINATION 9

Introduction - definition and meaning of terms used in illumination engineering - classification of light sources - incandescent lamps, sodium vapour lamps, mercury vapour lamps, fluorescent lamps – design of illumination systems - indoor lighting schemes - factory lighting halls - outdoor lighting schemes - flood lighting - street lighting - energy saving lamps, LED.

UNIT III HEATING AND WELDING 9

Introduction - advantages of electric heating – modes of heat transfer - methods of electric heating - resistance heating - arc furnaces - induction heating - dielectric heating - electric welding – types - resistance welding - arc welding - power supply for arc welding - radiation welding.

UNIT IV SOLAR RADIATION AND SOLAR ENERGY COLLECTORS 9

Introduction - solar constant - solar radiation at the Earth's surface - solar radiation geometry – estimation of average solar radiation - physical principles of the conversion of solar radiation into heat – flat-plate collectors - transmissivity of cover system - energy balance equation and collector efficiency - concentrating collector - advantages and disadvantages of concentrating collectors - performance analysis of a cylindrical - parabolic concentrating collector – Feedin Invertors.

UNIT V WIND ENERGY 9

Introduction - basic principles of wind energy conversion - site selection considerations - basic components of a WECS (Wind Energy Conversion System) - Classification of WECS - types of wind Turbines - analysis of aerodynamic forces acting on the blade - performances of wind.

TOTAL : 45 PERIODS

OUTCOMES:

Ability to understand and analyze power system operation, stability, control and protection.

Ability to handle the engineering aspects of electrical energy generation and utilization.

TEXT BOOKS:

1. N.V. Suryanarayana, "Utilisation of Electric Power", Wiley Eastern Limited, New Age International Limited,1993.
2. J.B.Gupta, "Utilisation Electric power and Electric Traction", S.K.Kataria and Sons, 2000.
3. G.D.Rai, "Non-Conventional Energy Sources", Khanna Publications Ltd., New Delhi, 1997.

REFERENCES:

1. R.K.Rajput, Utilisation of Electric Power, Laxmi publications Private Limited.,2007.
2. H.Partab, Art and Science of Utilisation of Electrical Energy", Dhanpat Rai and Co., New

Delhi, 2004.
3. C.L.Wadhwa, "Generation, Distribution and Utilisation of Electrical Energy", New Age International Pvt.Ltd., 2003.
4. S. Sivanagaraju, M. Balasubba Reddy, D. Srilatha,' Generation and Utilization of Electrical Energy', Pearson Education, 2010.

Subject code: EE6801 **Year/semester:IV/08**

Subject Name: Electric Energy Generation ,Utilization & Conservation

Subject Handler: S.Priya

UNIT- I ELECTRIC DRIVES AND TRACTION

Fundamentals of electric drive - choice of an electric motor - application of motors for particular services - traction motors - characteristic features of traction motor - systems of railway electrification - electric braking - train movement and energy consumption - traction motor control - track equipment and collection gear.

PART * A

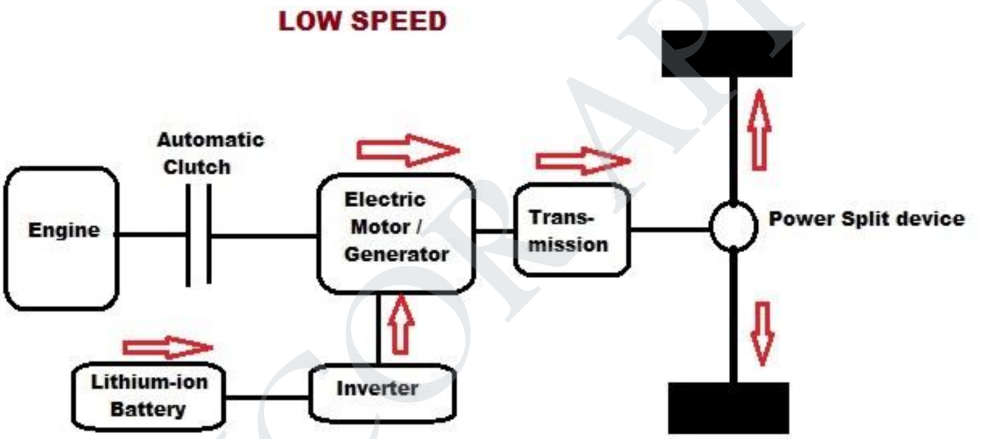
Q.No	Questions
1.	**What are the advantages of electric traction system? (Dec 2013, 2014)** BTL1 • In electric traction electric motors are used as the drives, the system is clean and pollution free and it has high starting torque therefore high acceleration is possible. • Electric traction is most suitable for urban and suburban areas where frequent starting and stopping and high schedule speeds are required. • The coefficient of adhesion is high, therefore for the same tractive effort electric locomotives are lighter and hence higher speeds on gradients are possible. • Over loading of electric motors is possible. • Centre of gravity of electric locomotive is lower than that of steam locomotive.
2.	**What are the requirements of ideal traction system?**BTL1 • The coefficient of adhesion should be high, so that high tractive effort at start is possible and rapid acceleration of the train can be obtained. • It should be possible to overload the equipment for short periods. • It should be pollution free. • The locomotive or train unit should be self-contained. • It should be possible to use regenerative braking.
3.	**What are the supply systems for electric Traction?**BTL 1 The direct current system • The Single phase AC system • The 3 phase Ac system
4.	**How would you analyze the speed time curve for electric train?**BTL 3 • Acceleration • Speed Constant or free running • Period of wasting
5.	**Define crest speed of a train? (Dec 2012)** BTL1 It is the maximum speed of train, which affects the schedule speed as for fixed acceleration,

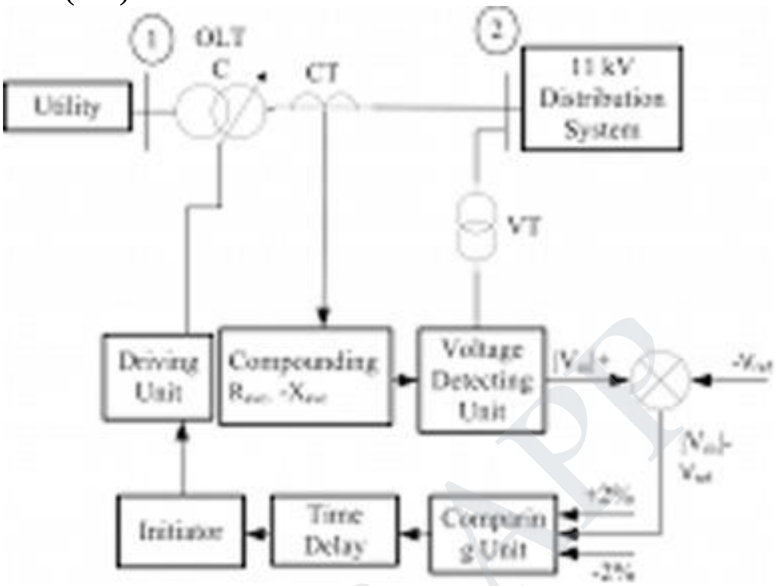
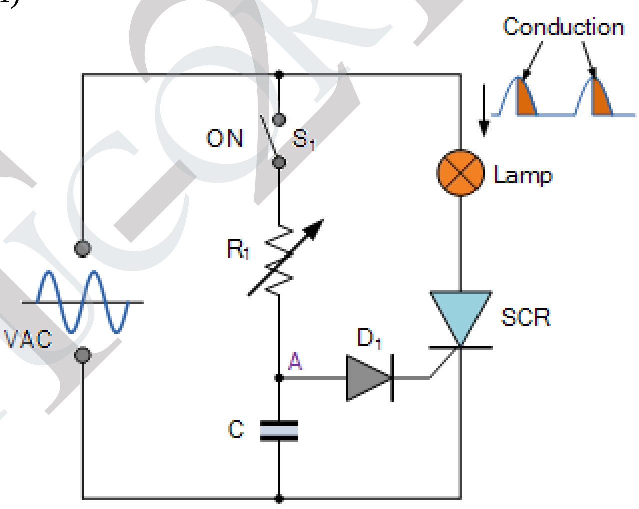
	retardation, and constant distance between the stops. If the crest speed increases, the actual running time of train decreases. The high crest speed of train will increases its schedule speed.
6.	**Define specific energy consumption and discuss the factors that affects the specific energy Consumption of trains operation at a given schedule speed. (Dec 2012) (May 2015)** BTL1 It is the energy consumed (in Wh) per tonne mass of the train per km length of the run. The specific energy consumption of a train running at a given schedule speed is influenced by 1. Distance between stops 2. Acceleration 3.Retardation 4.Maximum speed 5. Type of train and equipment 6. Track configuration.
7.	**What is Schedule speed?**BTL1 It is the ratio of the distance between the stops and the total time taken including time for stops to cover the distance isSchedule speed = Distance between stops in km/Actual time of run in hr+ Stop time in hr.
8.	**What are the factors affecting the schedule speed of a train?**BTL 1 • Crest speed • Acceleration • Breaking retardation
9.	**Define dead weight.** BTL1 • It is the gross weight of the train including locomotive to be moved on the rail track. The dead weight of the train comprises of ➢ The weight which has linear acceleration and ➢ The weight which has angular acceleration
10	**Define accelerating weight.** BTL1 Due to rotational inertia for angular acceleration the total effective weight of the train will be more than the dead weight. Thus effective weight is termed as accelerating weight of the train.
11	**What is tractive effort?**BTL2 It is an effective force on the wheel of a locomotive which is required for its propulsion. The tractive effort is a vector quantity and it is tangential to wheel. It is measured in newtons.
12	**Write the formula for tractive effort of an electric train? (Dec 2013)** BTL1 The tractive effort is given by $F_t = F_a + F_g + F_r$ Where F_a = Force to overcome linear or angular motion. F_g = Force to overcome effect of gravity. F_r = Tractive effort to overcome the frictional resistance.
	Why dc series motors are preferred for electric traction?BTL1 • Series motors exert high starting torque.

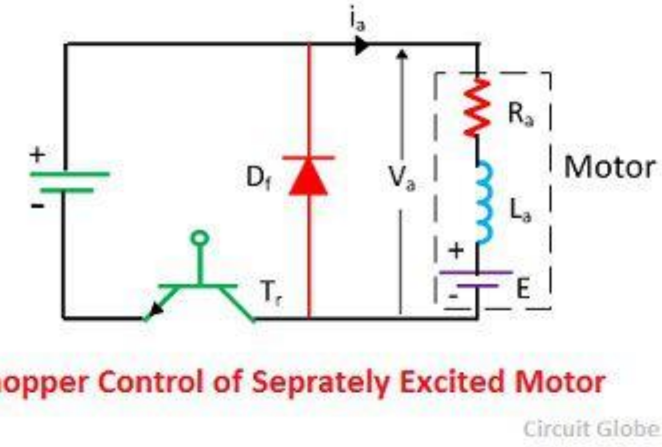
13	• If the torque is increased the speed of the series motor decreases automatically. • The free running speed of the series motor is sufficiently high.
14	**What are the mechanical characteristics of traction motor?**BTL2 • As the motor has to withstand the vibrations continuously the motor should be robust. • The motor should have minimum possible weight.
15	**Why a three phase induction motor is more suitable for traction purpose?**BTL1 • It has constant speed characteristics. • It has shunt type speed torque characteristics even during braking. • Possibility of applying regenerative braking on gradient. • Its robust construction in absence of commutator. • High efficiency.
16	**What is meant by electric braking?**BTL2 Electrical braking cannot do away with the mechanical brakes since a vehicle cannot be held stationary by its use; it nevertheless forms a very important part of traction system. The main advantage is that it reduces the wear on the mechanical brakes and gives a higher value of braking retardation, thus bringing a vehicle quickly to rest and cutting down considerably on the running time.
17	**What are the methods of electric braking?**BTL2 • Plugging • Rheostatic braking • Regenerative braking
18	**What is plugging?**BTL2 Plugging consists in reversing the connections of the armature of the motor so as to reverse its direction of rotation which will oppose the original direction of rotation of motor and will bring it to zero speed when mechanical brakes can be applied.
19	**What is rheostatic braking?**BTL2 In this method of braking, this motor is disconnected from the supply and run as a generator driven by the remaining kinetic energy of the equipment.i.e by the energy stored in motor and load which are to be braked.
20	**What is meant by dead man's handle device?**BTL2 With all types of controllers a dead man's handle device is provided in order to stop the train automatically in case the driver fails and /or is not in a position to control the operation. This is in the form of a contact attached to the knob of the controller handle. If the driver is not able to operate the handle properly, the knob raises which causes the contact to close and operate the main circuit breaker and apply the brakes.
21	**Write the formula for tractive effort of an electric train? (May 2014)** BTL2 The tractive effort is given by $F_t = F_a + F_g + F_r$ Where F_a = Force to overcome linear or angular motion, F_g = Force to overcome effect of gravity, F_r = Tractive effort to overcome the frictional resistance.

22	**What are the recent trends in electric traction? (May 2013)(May 2014)&(Dec 2014)** BTL1 Development of practical electric vehicles has been completed. Motor selection becomes clear, Battery trend becomes also clear, and Components are almost completed.
PART * B	
1.	**i) Explain the requirements of electric traction system.(3M)(Apr/May 2018)** BTL2 Answer Page: 3.69 – V.THIYAGARAJAN • The starting tractive effort should be high so as to have rapid acceleration. • The wear on the track should be minimum • Pollution free • Low initial and maintenance cost. **ii) Describe the mechanism of train movement with speed time curve. (10M) (Apr/May 2018)** BTL 3 Answer Page: 3.69 – V.THIYAGARAJAN • Diagram representation of transmission of tractive effort (4M) • Coefficient of adhesion (2M) It is defined as ratio of trcative effort to slip the wheels and adhesive weight. • Tractive effort for propulsion of train(4M)
2.	**What are the various types of electric braking used in traction? Discuss in detail. (13M) (May 2015)** BTL 2 Answer Page: 3.32 – V.THIYAGARAJAN **Braking: (2M)** The main theme of braking is to stop the motion or to oppose the motion. In braking, the motor works as a generator developing a negative torque which opposes the motion. **Types: (11M)** • **Regenerative braking**: In regenerative braking, generated energy is supplied to the source under the condition E> V and negative Ia. • **Dynamic or rheostatic braking**: Regenerative braking is not possible if it is impossible for the motor speed to be greater than the no load speed. • **Counter current braking (or) plugging**: ➢ For quick stopping of the motor ➢ For reversing drives requiring a short time for reversal.
3.	**i) Explain the principle and operation of a modern ac locomotive. (6M) (May 2015)**BTL2 Answer Page: 3.32 – V.THIYAGARAJAN

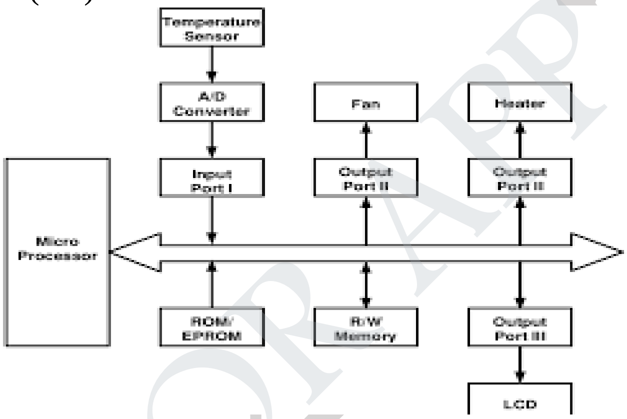
	• The cost of electronic devices in a modern locomotive can be up to 50% of the cost of the vehicle. Electric traction allows the use of regenerative braking, in which the motors are used as brakes and become generators that transform the motion of the train into electrical power that is then fed back into the lines. **ii) What are the factors influencing the choice of electric drives? (7M) (Apr/May 2017)** BTL1 Answer Page: 3.50 – V.THIYAGARAJAN **Selection of electric motors:** • Speed – torque characteristics matching between motor and load. • Type of power supply available • Initial and running costs • Availability of spare parts and trained personnel.
4.	**Define specific energy consumption and discuss the factors that affects the specific energy consumption of trains operation at a given schedule speed. (13M) (Dec 2012)** BTL 3 Answer Page: 3.101 - V.THIYAGARAJAN • **Factors & explanation (13M)** 1. Distance between the stops: The greater the distance between the stops, the lesser will be specific energy consumption. The specific energy consumption for suburban service is 50 to 75 watts hour/tonne km. 2. Train resistance: The train resistance depends upon the nature of track, speed of the train and shape of rolling stock, particularly the front and rear portions of the train. 3. Acceleration and retardation: If the acceleration and retardation increases, the specific energy consumption is increased. 4. Gradient: The steep gradients will involve more energy consumption through regenerative braking is applied. 5. Train equipment: More efficient train equipment will reduce the specific energy consumption.
5.	**Explain regenerative braking when used for DC series traction motors. How does it differ from the regenerative braking as used for shunt motors? (13M) (Dec 2012)** BTL 2 Answer page: 3.36 - V.THIYAGARAJAN • **Definition (2M):** Regenerative braking is an energy recovery mechanism which slows a vehicle or object by converting its kinetic energy into a form which can be either used immediately or stored until needed. In a nutshell, the electric motor is using the vehicle's momentum to recover energy that would be otherwise lost to the brake discs as heat. • **Regenerative braking (11M):**

	• Power input to an induction motor is given by Pin= 3V Is cosØs Where Øs is the phase angle between stator phasor voltage v and the stator phase current Is. For motoring operation Øs< 90. • Regenerative braking is not by itself sufficient as the sole means of safely bringing a vehicle to a standstill, or slowing it as required, so it must be used in conjunction with another braking system such as friction-based braking. • The regenerative braking effect drops off at lower speeds, and cannot bring a vehicle to a complete halt reasonably quickly with current technology, although some cars like the Chevrolet Bolt can bring the vehicle to a complete stop on even surfaces when the driver knows the vehicle's regenerative braking distance. This is referred to as One Pedal Driving. 
6.	**Draw the speed time curve of a traction system. Also explain various speeds and actions. (13M) (Dec 2013)** BTL 4 Answer Page: 3.76 – V.THIYAGARAJAN Speed – Time curves consists of 1. Acceleration period(4M) 2. Free run or constant speed period(3M) 3. Coasting period(3M) **4.** Retardation period(3M)
7.	**Explain about multi motor speed control. (13M) (May 2015)** BTL 2

	Answer Page: 3.111 – V.THIYAGARAJAN Methods & Explanation • Tap changer control(4M)  • Thyristor control(3M)  • Chopper control(3M)



- Microprocessor control(3M)



8. **Explain the DC series traction motor control. (13M) (May 2014)** BTL 2

Answer Page: 3.102 – V.THIYAGARAJAN

Speed control methods: (13M)

1. Rheostatic control

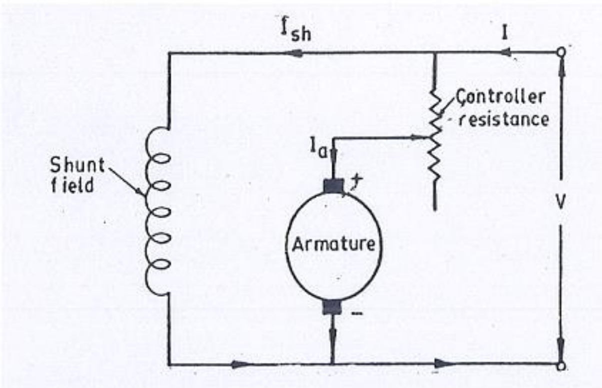
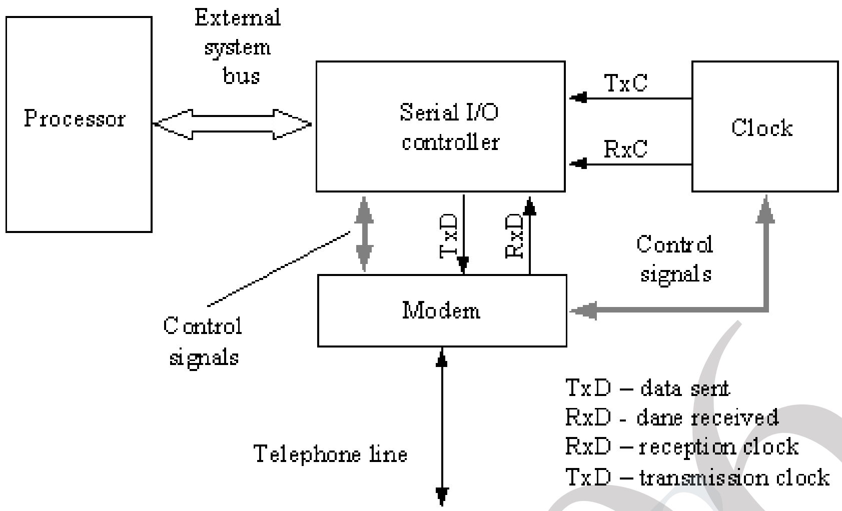
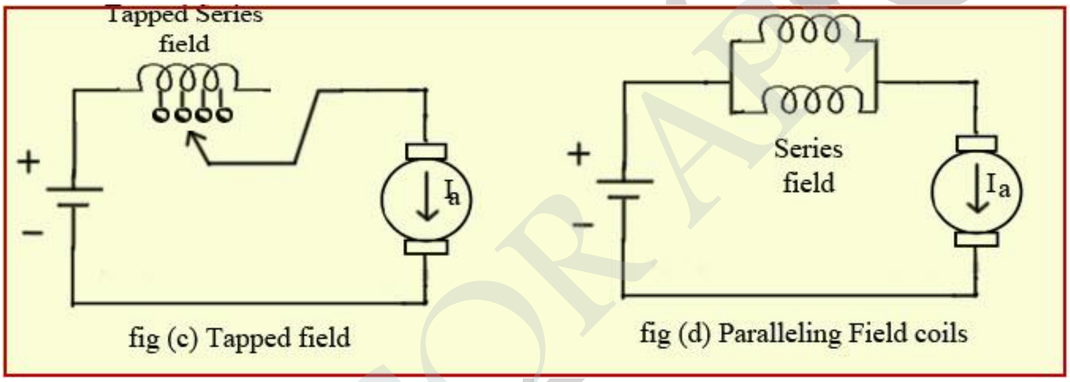


Fig. 86. Armature resistance control for D.C. shunt motor.

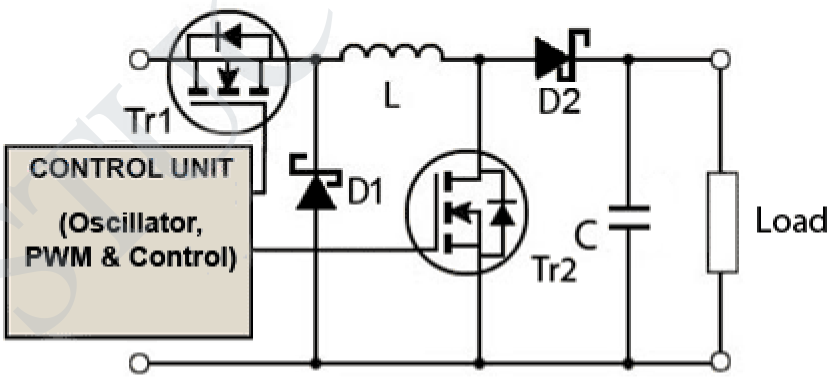
2. Series parallel control



3. Field control



4. Buck and boost method



5. Metaldyne control
6. Thyristor control

9. **A 250 tones EMU train is started with a uniform acceleration and reaches a speed of 30km/hr in 20 seconds on level section. Find the specific energy consumption assuming a simplified trapezoidal curve, with rotational inertia as 8 %, retardation as 3 km/hr/sec, the distance between two stations as 4km, efficiency of motor as 0.9 and train resistance 4 kg/tonne.(13 M)(Dec 2012).**BTL 3

Answer page: M.Q.1- V.Thiyagarajan

	We/W= 1.08 upon rotational inertia Resistance of motion r= 4 * 9.81 = 39.24 newton/ tonne Braking duration t3= Vc/β = 10 sec Distance travelled during braking is D D= ½ * Vm* t3/3600 = 3.9583 Km Specific energy output Eo= 0.01072 V_M2/D * W_e/W Specific energy consumption = 13.39206/0.9 = 14.88 wh/tonne –Km
	PART*C
1	**A train weighing 200 tones acceleration uniformly from rest to a speed of 50 km/hr up a gradient of 1 in 500, the time taken being 35 seconds. The power is then cut off the train coasts down a uniform gradient of 1 in 1000 for a period of 40 seconds when brakes are applied for period of 15 seconds so as to bring the train uniformly to rest on this gradient.** **Calculate** **1. The maximum power output from the driving axle.** **2. The energy taken from the conductor rails in kWh.** **Assuming an efficiency of 70% and assume tractive effort to be 40 Newtons per tonnes at all speed and allow 10% for rotational inertia. (May 2013)(15M)**BTL 2 **Sol:** W= 200 tonnes **V**$_m$ = 50 km/hr R= 3 km/hr/sec G= 1/500 = 2% We/W= 1.1 upon rotational inertia Effective weight of train We= 1.1. W=1.1 * 200=200 tones Required tractive effort Ft= 277.8 We α + 9.81 W G Wr Newtons Ft= 99232.5 Newtons The maximum power output from the driving axels = Ft. Vm/ 3600 Total energy required for the run = Energy required for acceleration as there is no free run.

2	**A suburban electric train has a maximum speed of 80km/hr. The schedule speed including a station stop of 30 seconds is 50 km/hr. If the acceleration is 2 km/hr/sec, find the value of retardation when the average distance between stops is 4KM. (8M)(May 2015)**BTL 2 **Sol:** Vm= 80 km/hr Duration of stop= 30 seconds α = 2km/hr Schedule time of run Ts= 3600 * D/Vs=288 seconds.

UNIT- II ILLUMINATION

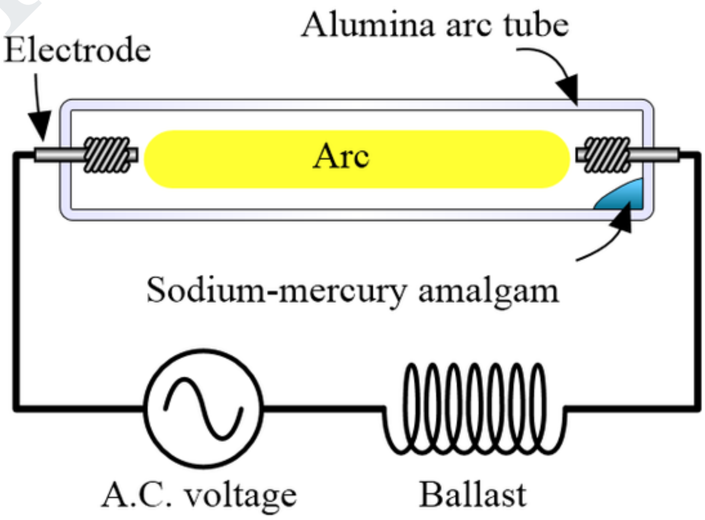
Introduction - definition and meaning of terms used in illumination engineering - classification of light sources - incandescent lamps, sodium vapour lamps, mercury vapour lamps, fluorescent lamps – design of illumination systems - indoor lighting schemes - factory lighting halls - outdoor lighting schemes - flood lighting - street lighting - energy saving lamps, LED.

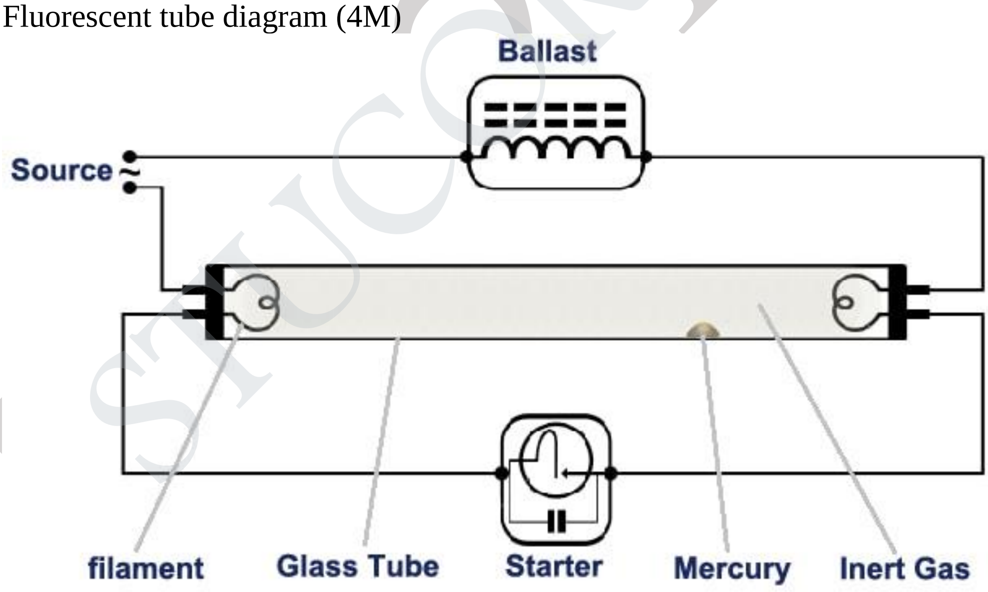
PART * A

Q.No	Questions
1.	**Define light.**BTL 1 Light may be defined as that radiant energy in form of waves which produces a sensation of vision upon human eye.
2.	**Define luminous flux.**BTL 1 Luminous flux is defined as the energy in the form of light waves radiated per second from a luminous body.Eg for a luminous body is an incandescent lamp.
3.	**Define illumination or illuminance or degree of illumination.**BTL 1 When the light falls on the surface it is illuminated. The illuminance is defined as the luminous flux received per unit area. Let the incident luminous flux on a small area dA be dFthen, Illuminance= dF/dA= lumens/area. = candle power x ω .
4.	**Define candle power.** BTL 1 Candle power is the number of lumens per unit solid angle. Candle power= lumens/ω.
5.	**Define plane angle.**BTL 1 When two straight lines lying in the same plane meet at a point, there will be an angle between these converging lines at the meeting point. This angle is termed as plane angle. The plane angle is represented by radians.
6.	**What is solid angle?**BTL 2 The angle subtended by a point in space by an area is termed as solid angle. This solid angle represents the volume which is enclosed by numerous lines lying on the surface and meeting at a point. It is denoted by the symbol ω.
7.	**Define luminous intensity.**BTL 1 The luminous intensity is the measure of luminous flux in lumens emitted per unit solid angle by a point source and is denoted by I. $I = \Phi/\omega$

8.	**What are the two laws of illumination?**BTL 2 • Inverse square law. • Lambert's cosine law.
9.	**State inverse square law.**BTL 1 This law states that illumination of a surface is inversely proportional to the square of the distance of the surface from the source of light, under the condition that source is the point source.
10	**State Lambert's law.**BTL 1 This law states that illumination of a surface at any point is dependent upon the cube of cosine of the angle between the line of flux and the normal at that point.
11	**Define MSCP, MHCP, MHSCP. MSCP.**BTL 1 • The mean or average of candle power in all directions in all planes is called MSCP. • **MHCP (Mean horizontal candle power) :** The mean or average of the candle power in all directions on a horizontal plane which passes through the source is called MHCP. MHSCP(Mean hemi spherical candle power). • The mean or average of candle power in all directions within the hemisphere either above the horizontal plane or below the horizontal plane.
12	**Define brightness or luminance.**BTL 1 It is defined as the flux emitted per unit area or the luminous intensity per unit projected area of the source in a direction perpendicular to the surface. The unit of brightness is candles per sq.m.
13	**Define lux.**BTL 1 It is defined as the illumination of the inside of the sphere of radius 1 metre at the centre of which there is a source of 1 candle power.
14	**If the total lumens required are 7200 and coefficient of utilization is 0.3, calculate lamp lumens required. (May 2015)** BTL 4 $\text{Utilization factor}=\frac{\text{Total lumens reaching the working plane}}{\text{Total lumens given out by the lamp}}$ $0.3=\frac{7200}{\text{Total lumens given out by the lamp}}$ $\text{Total lumens given out by the lamp}=\frac{7200}{0.3}$ $\text{Total lumens given out by the lamp} = 24000$
15	**Define utilization factor in the design of the lighting scheme.**BTL 1 Utilization factor is defined as the total lumens utilized on working plane to the total lumens radiated by lamp.
16	**What is depreciation factor?**BTL 2 Depreciation factor is defined as the illumination under normal working condition to illumination

	when everything is clean. So this occurs when the source is not clean. (eg. Lamps covered with dust, dirt or smoke.
17	**State the different lighting scheme.**BTL 6 Depending upon the requirement of light the lighting schemes can be classified as follows. • Direct lighting • Indirect lighting • Semi direct system of lighting • Semi indirect lighting • General diffusing system.
18	**List the various factors for designing the lighting scheme.** BTL 4 The various factors should be taken into consideration for designing the lighting scheme are • Space height ratio • Utilization factor • Depreciation factor
19	**Define space height ratio.**BTL 1 Space height ratio= the horizontal distance between the lamps/ Mounting height of lamps
20	**Define waste light factor.**BTL 1 When a surface is illuminated by number of lamps, there is certain amount of wastage due to overlapping of light waves. Its value for rectangular areas= 1.2.Irregular areas= 1.5.
21	**Mention some of the reflectors commonly used in industrial lighting.**BTL 3 • Standard reflectors. • Diffusing fitting. • Concentrating reflectors • Angle reflectors.
22	**Define lumen. (May 201)]/(Dec 2014)** BTL 1 Lumen is the unit of flux and is defined as the luminous flux per unit angle from a source 1 candle power. Lumens= candle power x solid angle= candle power x ω
23	**List the type of lighting system. (May 2013]/[Dec 2014)** BTL 4 Incandescent, Tungsten-halogen, Compact Fluorescent Lamps, Tubular fluorescent fixtures, High- intensity discharge (HID)
24	**Why tungsten is used as filament material? (Dec 2013)** BTL 6 Pure tungsten has properties including the highest melting point (3695 K), lowest vapour pressure, and greatest tensile strength out of all the metals.

25	**What is the importance of street lighting system? (Dec 2012)** BTL 3 1. To reduce the occurrence of accident. 2. To avoid the theft
	PART * B
1.	**What are the properties of good lighting? Explain in detail about Laws of illumination.(13M)(May 2014,2015)**BTL 1 Answer page : 4.3 & 4.9 – V.THIYAGARAJAN Properties: (4M) • Lighting scheme should be able to produce sufficient light. • It should not produce any glare in the eyes • It should have sufficient shades and reflectors • It should be of correct type as needed Laws of illumination: (9M) • **Laws of inverse squares:** "Illumination at a point is inversely proportional to square of its distance from the point source and directly proportional to the luminous intensity (CP) of the source of light in that direction. • **Lamberts cosine law:** "The illumination at a point on a source is proportional to cosine of the angle which may makes with the normal to the surface at that point.
2.	**Explain with sketch the principle of working of a sodium vapour lamp and enumerate its advantages and disadvantages as source of light?(13M)**BTL 2 Answer page : 4.33 – V.THIYAGARAJAN • Sodium vapour discharge lamp diagram (4M)  • Construction & working (6M)

	1. A sodium-vapour lamp is a gas-discharge lamp that uses sodium in an excited state to produce light at a characteristic wavelength near 589 nm. 2. Two varieties of such lamps exist: low pressure and high pressure. Low-pressure sodium lamps are highly efficient electrical light sources, but their yellow light restricts applications to outdoor lighting, such as street lamps. • Advantages and dis advantages (3M) Adv: 1. Its efficiency is higher than that of the filament lamp 2. It has a long life. Dis-Adv: 1. The bright yellow colour obtained is not suitable for indoor lighting. So it is not useful in house. 2. For the necessary output, long tubes are required.
3.	**Explain the working of fluorescent tube with the help of the circuit diagram giving the function of various parts. How stroboscopic effect is eliminated in fluorescent tube lighting?(13M)**BTL 2 Answer page : 4.43 – V.THIYAGARAJAN • Fluorescent tube diagram (4M)  • Construction & working (6M) 1. A **fluorescent lamp**, or **fluorescent tube**, is a low-pressure mercury-vaporgas-discharge lamp that uses fluorescence to produce visible light. 2. An electric current in the gas excitesmercury vapor, which produces short-wave ultraviolet light that then causes a phosphor coating on the inside of the lamp to glow. 3. A fluorescent lamp converts electrical energy into useful light much more efficiently than incandescent lamps. 4. The typical luminous efficacy of fluorescent lighting systems is 50–100 lumens per watt, several times the efficacy of incandescent bulbs with comparable light output.

- Advantages and dis advantages (3M)

Adv:

1. No Power factor correction
2. No stroboscopic effect.

Dis-Adv:

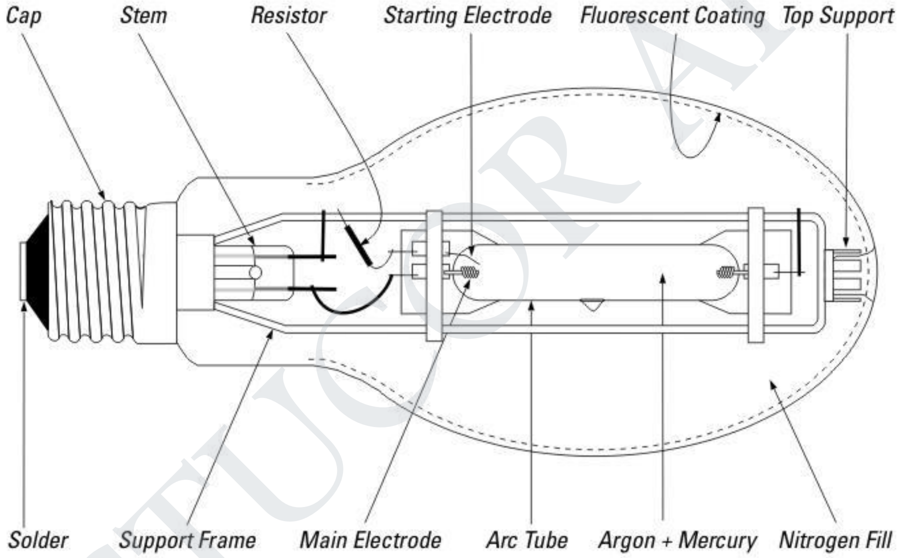
1. Low efficiency
2. More power loss
3. High cost

4.

Describe the construction and working of Mercury – vapour lamp and mention its advantages and disadvantages.(13M)(Dec 2012, May 2014) BTL 4

Answer page : 4.36 – V.THIYAGARAJAN

- Mercury vapour lamp diagram (4M)



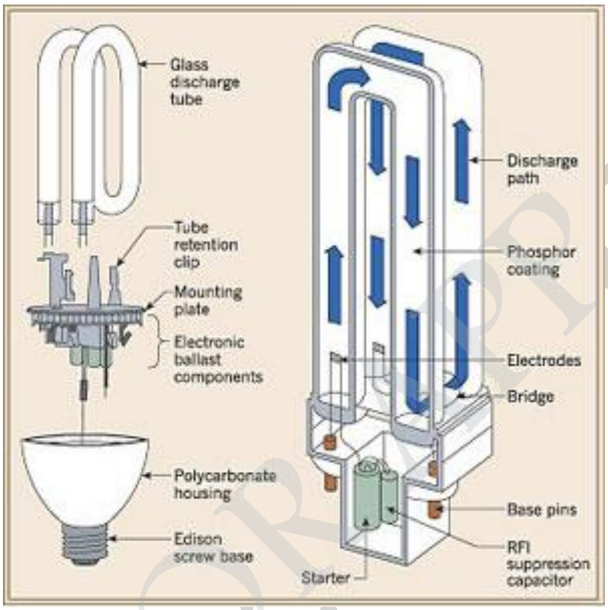
- Construction & working (6M)
  1. A **mercury-vapor lamp** is a gas discharge lamp that uses an electric arc through vaporized mercury to produce light.
  2. The arc discharge is generally confined to a small fused quartzarc tube mounted within a larger borosilicate glass bulb.
  3. The outer bulb may be clear or coated with a phosphor; in either case, the outer bulb provides thermal insulation, protection from the ultraviolet radiation the light produces, and a convenient mounting for the fused quartz arc tube.
- Advantages and dis advantages (3M)

Adv:

1. Its efficiency is high and output is more
2. It has a long life.

Dis-Adv:

	1. The initial time required for warming up is more about 5 minutes 2. Each lamp contains mercury which can be harmful to both humans and wildlife.
5.	**Explain the various factors to betaken into account for designing schemes for 1.Street lighting. 2. Flood lighting. 3. High way lighting.(13M)(Dec 2012 /Dec 2013)/(May 2014)** BTL 2 Answer page : 4.67 – V.THIYAGARAJAN • Design of outdoor lighting& explanation (8M) 1. Flood lighting: a. Aesthetic flood lighting b. Industrial and commercial flood lighting c. advertising 2. Street lighting a. The diffusion principle b. The specular reflection principle • Flood lighting calculations (5M) Step 1: Illumination level required Step 2: type of projector Step 3: number of projector
6.	**Explain the design procedure of illumination system. Mention the requirements of good lighting.(13M)**BTL 2 Answer page : 4.62 – V.THIYAGARAJAN **Objective:** (4M) • To provide adequate illumination • To provide light distribution all over the area uniformally • To provide light of suitable colour • To avoid glare and hard shadows. **Steps:** (9M) • Calculate area to be illuminated • Decide the level of illumination • Total illumination = area illumination level • Select utilization factor and depreciation factor • Divide total illumination by utilization factor and depreciation factor • Select lamp and luminaries.

7.	**With the neat diagram explain the construction and working of CFL lamp. (13M) (May 2015)** BTL 2 Answer page : 4.47 – V.THIYAGARAJAN • **CFL diagram** (4M)  • **CFL Features**(4M) 1. It is fluorescent lamp designed to replace an incandescent lamp 2. Some types fit into light features formerly used for incandescent lamp. 3. Smaller in size 4. Different shapes-folded, spiral, circular 5. Available in 9 watt to 26 watt 6. It saves 75 % of energy • **Lamp life and efficiency** (5M)
8.	**i) Explain the various steps followed in the calculation of illumination for designing the residential lightning. (13M) (May 2015)** BTL 4 Answer Page: 4.62- J.Gnanavadivel • Design methodology(13M) 1. Calculate area to be illuminated 2. Decide the level of illumination 3. Total illumination= Area illumination level 4. Select utilization factor and depreciation factor 5. Divide total illumination by utilization factor and depreciation factor.
	PART * C

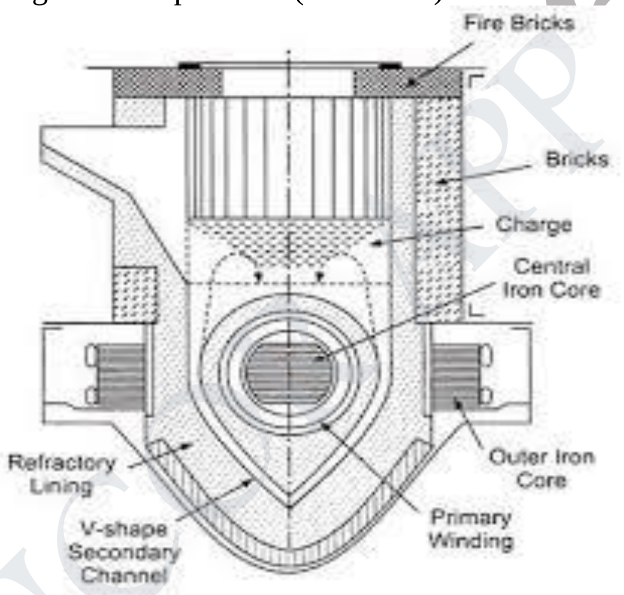
1	**A drawing hall 30x15 meters with a ceiling height of 5 meters is to be provided with a general illumination of 120 lux. Taking a coefficient of utilization of 0.5 and depreciation factor 1.4, determine the number of fluorescent tubes required , their spacing mounting height and total wattage. Tasking luminous efficiency of fluorescent tube as 40 lumens/watt for 80 watt tube. (15M) (May 2017)**BTL 4 **Sol:** A= 30 * 15 = 450 m^2 E= 120 lumens/m^2 U.F= 0.5 Mf=1/142 Luminous efficiency of fluorescent tube = 40 lumens/watt Gross lumens required = A* E/ UF* MF= 153360 lumens Total wattage required= 3834 W No of fluorescent tubes required = 3834/80= 48.
2	**A lamp rated 250V gives an illumination of 4000 lux and takes 2A from the mains. Find the efficiency of the lamp and MSCP. (8M)(May 2017)** BTL 4 Sol: wattage of the lamp= 250*2 = 500 W MSCP= F/4π= 4000/4π = 318.3 Efficiency of the lamp= 4000/ 500 = 8 lumen per watt

UNIT- III HEATING AND WELDING	
Introduction - advantages of electric heating – modes of heat transfer - methods of electric heating - resistance heating - arc furnaces - induction heating - dielectric heating - electric welding – types - resistance welding - arc welding - power supply for arc welding - radiation welding.	
PART * A	
Q.No	**Questions**
1.	**Why the electric heating is considered to be superior when compared to the other methods of heating? (Nov /Dec 2012)** BTL 3 • Cleanliness, • Ease of control • Uniform heating. • Low attention and maintenance cost.
2.	**What are the classifications of methods of electric heating?** BTL 2 • Power frequency method. ➢ Direct resistance heating ➢ Indirect resistance heating ➢ Direct arc heating. ➢ Indirect arc heating. • High frequency heating. ➢ Induction heating ➢ Dielectric heating
3.	**Write short notes on direct resistance heating.** BTL 2 In this method of heating, current is passed through the body to be heated. The resistance offered by the body to the flow of current produces ohmic losses I^2R which results in heating the body. This method is quite efficient and therefore it is employed in resistance welding, in the electrode boiler for heating water and in the salt furnace.
4.	**Write short notes on indirect resistance heating.** BTL 2 In this method the current is passed through a high resistance wire known as heating element. The heat produced due to I^2R loss in the element is transmitted by radiation or convection to the body to be heated. This method is used in room heater, immersion water heaters, and in various types of resistance ovens and salt bath furnaces.
5.	**What are the requirements of a good heating material? (Dec’14)** BTL 2 • High specific resistance • High melting point • Free from oxidation • Low temperature coefficient of resistance.
6.	**What is the principle of arc furnace?** BTL 2 When voltage across s two electrodes separated by an air gap is increased, a stage is reached when voltage gradients in the air gap is such that air in the gap becomes good conductor of electricity. Arc is said to exist when electric current passes through the air gap.

7.	**What are the characteristics of induction heating?** BTL 2 • The current flows on the outer surface of the metal disc and in so doing, heats this surface. • The current flow is restricted axially to the surface of the metal which is contained within the turn. • The heat energy is transferred to the metal at an rapid rate, much faster than any conventional method of heating metal. • The heat energy is generated within the metal without any physical contact between the source of electrical energy and the metal being heated. • If the current continues to flow in the disc, the surface would attain extremely higher temperatures which can't be obtained by any other method.
8.	**Differentiate core type and coreless type induction furnaces.** BTL 4 Core type / Coreless type: The leakage reactance is very high / No leakage reactance Crucible of any shape can be used / Standard form is used Operation cost is high / Operation cost is low.
9.	**What are the advantages of Ajax Wyatt furnace?** BTL 2 • Good operating conditions for the refractory lining, no part of the furnace being hotter than the metal itself. • Accurate temperature control, uniform castings, minimum metal losses.
10	**What is the principle of dielectric heating? May 2012** BTL 2 When an insulating material is subjected to an alternating electric field, the atoms get stressed and due to the inter atomic friction heat is produced.
11	**What are the advantages of dielectric heating? Dec 2013** BTL 2 • This method of heating non conducting material can be done in the fast manner. • Normally material heated by this method is combustible which cannot be heated by the flame.
12	**What is meant by welding?** BTL 2 Welding is a process where in metals are joined together by fusion.
13	**What are the advantages of electric heating? May 2013, May 2014** BTL 2 • Economical • Cleanliness • Absence of flue gases • Ease of control or adaptation
14	**What are the causes of failure of heating elements?** BTL 2

	• Formation of hot spots • General oxidation of the element and intermittency of operation • Embrittlement caused by grain growth • Contamination of element or corrosion.
15	**Write short note on infrared heating? Dec, 2015** BTL 3 In radiant heating, the elements are of tungsten operating about 2300 c as at this temperature a greater proportion of infra-red radiation is given off. Heating effect on the charge is greater since the temperature of the heating element is greater than in the case of resistance heating.
16	**What are the different types welding?**BTL 2 1. Gas welding: • Oxy acetylene • Air- acetylene • Oxy-hydrogen 2. Resistance welding • Butt welding • Spot welding • Projection welding • Percussion 3. Solid state welding • Friction • Ultrasonic • Diffusion • Explosive
17	**What are the modern welding techniques? June 2009**BTL 2 **Drawbacks of conventional welding methods:** • Excessive melting • Diffusion • Formation of inter metallic compounds • Tower ductility • Difficult to weld some metals Modern welding techniques are • Ultrasonic welding • Laser welding • Electron beam welding
18	**What is LASER welding?** BTL 2 LASER(Light Amplification stimulated emission of radiation) welding is a welding process that uses the heat from a laser beam impinging on the joint. The process is without a shielding gas and pressure.

19	**Compare DC welding & AC welding.**BTL 4 **DC Welding:** • Motor-generator set or rectifier is required in case of availability of ac supply; otherwise oil engine-generator set is required. • Two or three times of transformer • Non coated cheap electrodes can be used. **AC Welding:** • Only a transformer is required. • Operating efficiency is 85% high • Power factor is low
20	**Define resistance welding? (May 2013)** BTL 1 Electric resistance welding (ERW) refers to a group of welding processes such as spot and seam welding that produce coalescence of faying surfaces where heat to form the weld is generated by the electrical resistance of material vs. the time and the force used to hold the materials together during welding.
21	**Give the methods of control temperature in arc furnace? (Dec 2012)**BTL 4 1.Changing the resistance of elements. 2.Changing the applied voltage to the elements (or) current passing through the elements. **3.**Changing the ratio of the on-and-off times of the supply.
22	**List some steps taken to minimize skin effect in induction heating? (Dec 2012)**BTL 4 1.By using copper-clad steel wire 2.By using low frequency 3.By reducing the thickness of the laminate or strips 4.By using hollow conductor
23	**What is meant by electric arc welding? What are the different types of electrodes used and its applicability?[May 2014]/[Dec 2014]**BTL 2 Arc welding is a type of welding that uses a power supply to create an electric arc between an electrode and the base material to melt the metals at the welding point. They can use either direct (DC) or alternating (AC) current, and consumable or non-consumable electrodes. purpose is to join two metals. Fabrication, ship building and riveting.
24	**Mention the factors which limit the choice of frequency in induction and dielectric heating? (May 2015)**BTL 4 **Induction Heating:** a) Thickness of the surface to be heated b) Time of continuous heating c) Temperature. **Dielectric Heating:** a) Thickness b) Potential gradient c) breakdown voltage d) insulation

25	**What is meant by arc welding and also list its types? May 2015**BTL 2 Arc welding is a type of welding that uses a power supply to create an electric arc between an electrode and the base material to melt the metals at the welding point. Different types of arc welding are Flux-cored arc welding (FCAW), Gas metal arc welding (GMAW),Gas tungsten arc welding (GTAW), Plasma arc welding, Shielded metal arc welding, Submerged arc welding.
	PART * B
1.	**Explain with neat sketch the principle and operation application and control methods of Ajax Wyatt furnace. (13M) (May 2014)**BTL 2 Answer Page: 5.23- V.Thiyagarajan • Ajax wyatt furnaces diagram & Explanation(6M & 7M)  • **Fig. 3.13** *Ajax-Wyatt Vertical Core type Furnace* • The induction heating works on the transformer principle. It is also known as eddy current heating. The currents are induced by the principle of electromagnetic induction. The induction heating may be low frequency as in the case of core type induction furnace or high frequency as the case with coreless induction furnaces. Types of Induction Heating 1. Direct Induction Heating. 2. Indirect Induction Heating. • Advantages: 1. Better power factor 0.8 to 0.93 2. No changes of pinch effect due to heavy weight of the metal over "Vee" portion. 3. It has the shape of a crucible.
2.	**i) Explain the process & various methods of electric arc welding. (May 2013) (8M)** BTL 2 Answer page: 5.53 - V.Thiyagarajan

<table>
<tr><td></td><td>

- Carbon arc welding
- Metal arc welding
- Atomic hydrogen arc welding
- Inert gas metal arc welding
- Submerged arc welding

ii) Compare AC & DC Welding.(5M)BTL 4

Answer page: 5.70 - V.Thiyagarajan

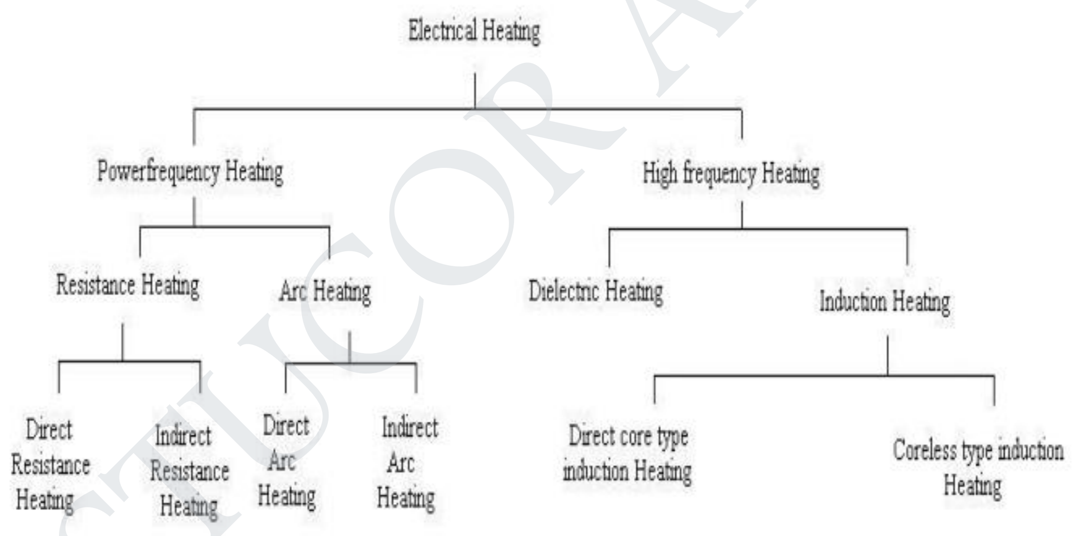
- Welding is the joining of two or more metal parts by melting them together.
- This process is unlike soldering, which is simply attaching two metal surfaces together via a piece of molten metal.
- Because the melting points of most metals are so high, specialized welding equipment uses the heat from an electric current to weld metal together.

</td></tr>
<tr><td>3.</td><td>

What are the different methods of heating? Describe briefly the methods of direct and indirect resistance heating?(13M)BTL 2

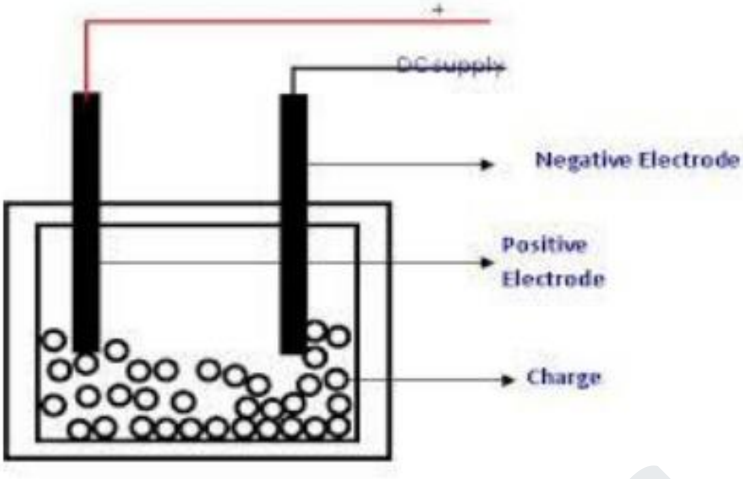
Answer page: 5.10 - V.Thiyagarajan

- Classification (3M)

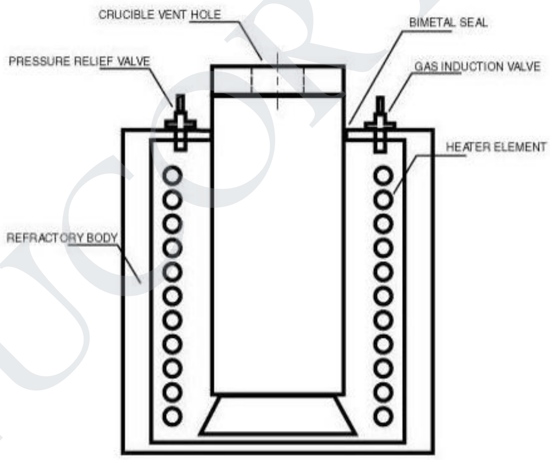


- **Direct Resistance Heating(**5M)
- In this method of heating the material or change to be heated is taken as a resistance and current is passed through it.
- The charge may be in the form of powder pieces or liquid. The two electrodes are immersed in the charge and connected to the supply.
- In case of D.C or single phase A.C two electrodes are required but there will be three electrodes in case of three phase supply.
- When metal pieces are to be heated a powder of high resistivity material is sprinkled over the surface of the charge to avoid direct short circuit.

</td></tr>
</table>



- **Indirect Resistance Heating:** (5M)
- In this method the current is passed through a highly resistance element which is either placed above or below the over depending upon the nature of the job to be performed.



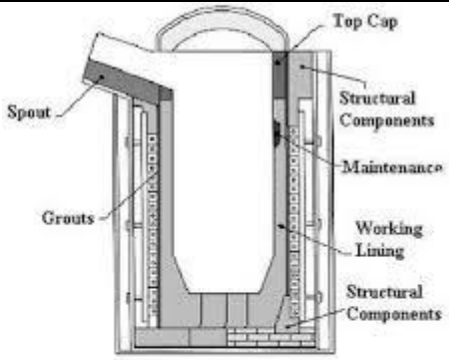
- The heat proportional to I2R losses produced in heating element delivered to the charge either by radiation or by convection.
- Sometimes in case of industrial heating the resistance is placed in a cylinder which is surrounded by the charge placed in the jackes. The arrangement provides as uniform temperature.

4. **(i) Explain the method of controlling temperature in resistance heating? (7M)(Dec 2013)** BTL 3

Answer Page : 5.17- J.Gnanavadivel

- Voltage/ current
- Using auto – transformer or induction regulator
- By series impedance

	• By variable voltage supply • Time • Resistance **(ii) What are the requirements of good welding? (6M)(Dec 2013)**BTL 2 • **Penetration**: how far the weld penetrates into the joint, often expressed a percentage. This is a combination of how the joint is prepared and set up, the process used and the current/voltage applied. It is possible to have both too little (weak joint) and too much (poor finish in the back side of the joint) penetration. • **Defects** : including porosity caused by contamination of the weld due to inadequate preparation/cleaning or inadequate shielding, craters caused by reducing current too rapidly at the end of a run, cold starts (poor penetration at the start of a run) • **Undercutting**: thinning of the parent metal at the edges of the weld usually caused by not enough filler metal relative to current.
5.	**Mention the properties of heating element. Explain the design procedure of heating element. (13M)** BTL 4 Answer page: 5.18 – V.Thiyagarajan • Properties of heating element:(6M) 1. High resistivity 2. High melting point 3. Free from oxidation 4. Low temperature coefficient 5. Ductile • Design procedure of heating element: (7m) 1. To determine the length and size of the heating element. 2. Stefan's law (H): In high temperature furnace, whatever heat is produced in the resistance of the element has to be radiated to the charge according to Stefan's law. 3. Causes of failure of heating elements: a) Formation of hot spots b) General oxidation of the element and intermittency of operation c) Embrittlement cause by grain growth.
6.	**i) Describe the construction and operation of the coreless induction furnaces.(8M) (Apr 2017)** BTL 4 Answer Page: 5.26 – V.Thiyagarajan • Coreless induction furnace (4M)

	 • Working (4M) 1. The principle of induction melting is that a high voltage electrical source from a primary coil induces a low voltage, high current in the metal, or secondary coil. Induction heating is simply a method of transferring heat energy. 2. Induction furnaces are ideal for melting and alloying a wide variety of metals with minimum melt losses, however, little refining of the metal is possible. There are two main types of induction furnace: coreless and channel. **ii) Explain the process of dielectric heating and derive the expression for total heat energy. (5M) (Apr 2017)**BTL 3 Answer Page: 5.28 – V.Thiyagarajan • Dielectric heating, also known as electronic heating, RF (radio frequency) heating, and high-frequency heating, is the process in which a radio frequency alternating electric field, or radio wave or microwaveelectromagnetic radiation heats a dielectric material. At higher frequencies, this heating is caused by molecular dipole rotation within the dielectric. • RF dielectric heating at intermediatefrequencies, due to its greater penetration over microwave heating, shows greater promise than microwave systems as a method of very rapidly heating and uniformly preparing certainfood items, and also killing parasites and pests in certain harvested crops.
7.	**Explain with neat sketch the principle and operation application and control methods of direct and indirect arc furnaces. (13M)**BTL 3 Answer Page: 5.30 – V.Thiyagarajan • **Introduction (3M)** • When a high voltage is applied across an air gap, the air in the gap gets ionised under the influence of electrostatic forces and becomes conducting medium. • Current flows in the form of a continuous spark, called the arc. It is to be noted that a very high voltage is required to establish an arc across an air gap but to maintain an arc small voltage may be sufficient. • **Types (2M)** • **Direct arc furnace** • **Indirect arc furnace** • **Direct Arc Furnace (4M):**

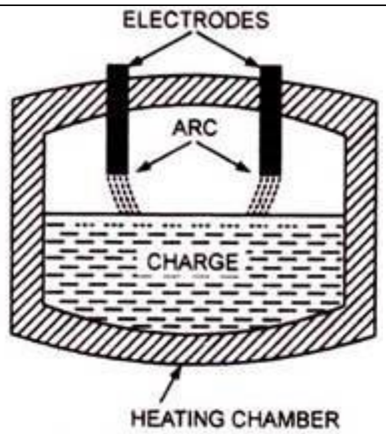
<table>
<tr><td></td><td>


Fig. 5.4. Direct Arc Furnace

In a direct arc furnace charge acts as one of the electrodes and the charge is heated by producing arc between the electrodes and the charge.
Since in a direct arc furnace, the arc is in direct contact with the charge and heat is also produced by flow of current through the charge itself, the charge can be, therefore, heated to highest temperature.
Indirect arc furnace(4M)

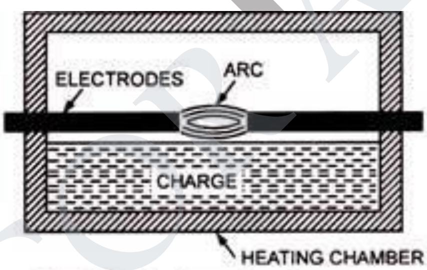


Fig. 5.5. Indirect Arc Furnace
</td></tr>
<tr><td>8.</td><td>
Discuss in detail about any two types of resistance welding. (13M) (Dec 2014) BTL 3
Answer page: 5.37 – V.Thiyagarajan

Resistance welding (5M)
Electric resistance welding (ERW) refers to a group of welding processes such as spot and seam welding that produce coalescence of faying surfaces where heat to form the weld is generated by the electrical resistance of material combined with the time and the force used to hold the materials together during welding.
Some factors influencing heat or welding temperatures are the proportions of the workpieces, the metal coating or the lack of coating, the electrode materials, electrode geometry, electrode pressing force, electrical current and length of welding time.
Small pools of molten metal are formed at the point of most electrical resistance (the connecting or "faying" surfaces) as an electrical current (100–100,000 A) is passed through the metal.
Types & explanation (8M)
1. Spot welding
2. Seam welding
3. Projection welding

</td></tr>
</table>

	4. Butt welding 5. Upset butt welding 6. Flash-butt welding 7. Percussion welding
9.	**i) Explain the principle of arc welding and the difference between carbon and metal arc welding and their relative merits and demerits.(8M)(May 2015)**BTL 2 Answer Page: 5.51 – V.Thiyagarajan • Principle of arc welding: (3M) 1. Arc welding is a welding process that is used to join metal to metal by using electricity to create enough heat to melt metal, and the melted metals when cool result in a binding of the metals. 2. It is a type of welding that uses a welding power supply to create an electric arc between a metal stick ("electrode") and the base material to melt the metals at the point-of-contact. Arc welders can use either direct (DC) or alternating (AC) current, and consumable or non-consumable electrodes. • Types of Arc welding(5M) 1. Carbon arc welding 2. Metal arc welding 3. Atomic hydrogen arc welding 4. Inert gas metal arc welding 5. Submerged arc welding **(ii) Explain the characteristicsprinciple and working of welding transformer. (5M) (May 2015)** BTL 2 Answer page: 5.73- V.Thiyagarajan • Welding Transformers are used in AC machines to change alternating current from the power line into a low-voltage, high amperage current in the secondary winding. A combination of primary and/or secondary taps on the welding transformer are commonly used to provide a macro adjustment of the welding current, as well as adjustment of secondary voltage. • Transformer ratings for AC machines are expressed in KVA (kilovolt-amperes) for a specified duty cycle. This duty cycle rating is a thermal rating, and indicates the amount of energy that the transformer can deliver for a stated percentage of a specific time period, usually one minute, without exceeding its temperature rating. • The RMS Short Circuit Secondary Current specification indicates the maximum current that can be obtained from the transformer. Since heating is a function of the welding current, this parameter gives an indication of the thickness of the materials that can be welded.
	PART * C
1	**Calculate the energy required to melt one metric ton of brass in a single phase induction furnace. If the time taken is 1.5 hr, find the power input to the furnace. Specific heat of brass=0.094, latent heat of fusion of brass= 38 kcal/kg, melting point of brass=920 c, furnace efficiency= 80%, Temperature of charge= 20 c. (15M) (May ’17)**BTL 4 **Sol:** Heat required to melt 1000kg of brass= 38* 1000= 38,000 kcal Heat required to raise the temperature to 920 C= 84600 kcal

	Total heat required = 122600 kcal Input heat required for the furnaces= 153200 kcal Power rating of furnace = 118.76 KW-hr.
2	**Estimate the efficiency of a high efficiency induction furnace which takes 15 minutes to melt 2kg of aluminum. The input to the furnace being 5KW and initial temperature 15C.** **(15M) (Apr'16)** BTL 4 **Sol:** Specific heat of aluminum = 880 j/kg/c Melting point of aluminum = 660 c Latent heat of fusion of aluminium= 32 kJ/Kg; 1J= 2.78 x 10^{-7} kWh Quantity of aluminium to be met , m= 2kg Initial temp, t1= 15c Melting temp, t2= 660 c Heat required to melt 2 kg of aluminium =1199200J Energu input= 1.25 kwh Efficiency = output/input * 100=26.64 %

UNIT- IV SOLAR RADIATION & SOLAR COLLECTORS

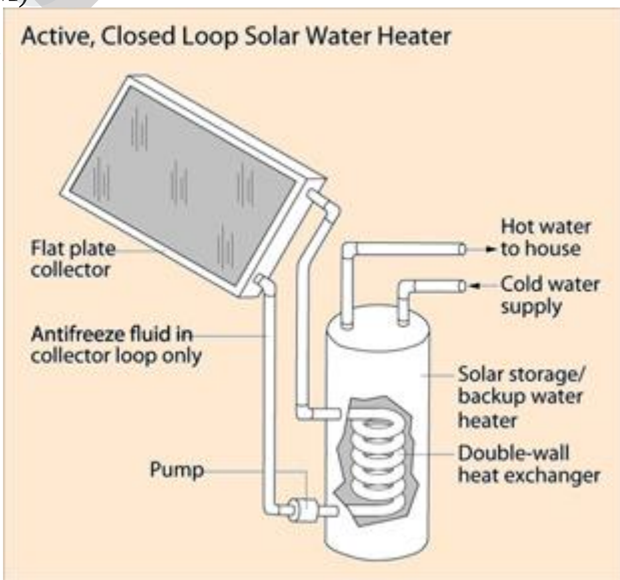
Introduction - solar constant - solar radiation at the Earth's surface - solar radiation geometry – estimation of average solar radiation - physical principles of the conversion of solar radiation into heat– flat-plate collectors - transmissivity of cover system - energy balance equation and collector efficiency - concentrating collector - advantages and disadvantages of concentrating collectors - performance analysis of a cylindrical - parabolic concentrating collector – Feeding Invertors.

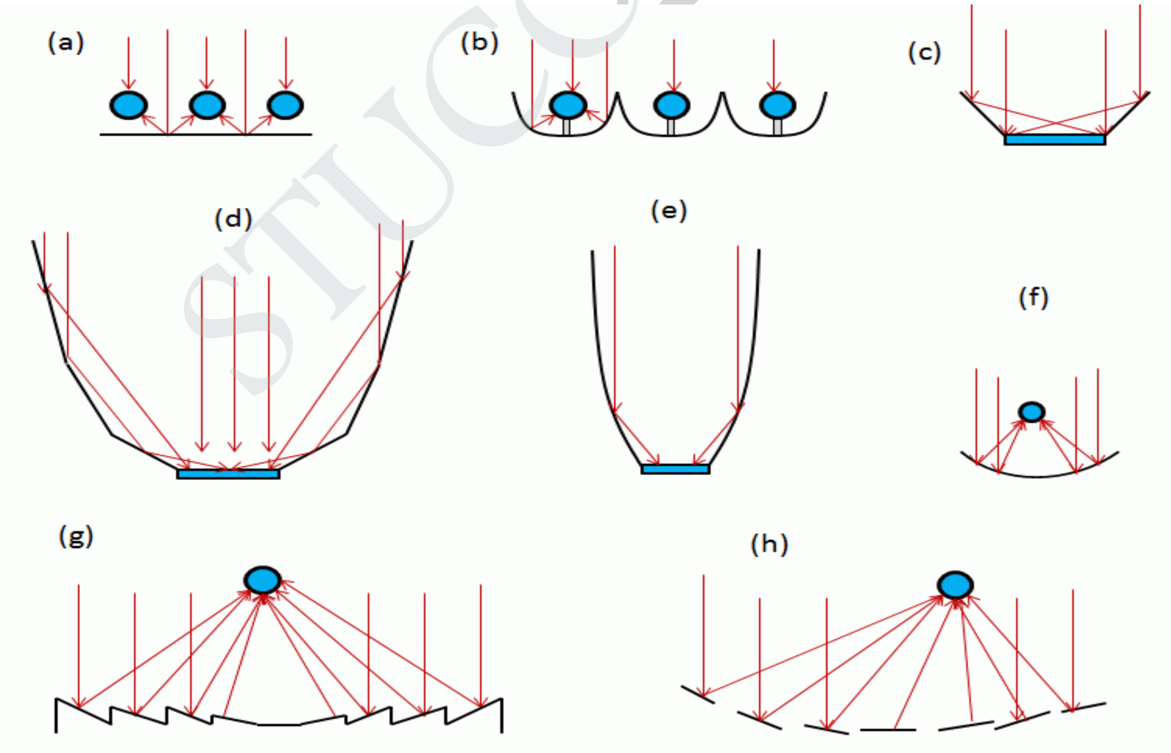
PART * A

Q.No	Questions
1.	**Define solar constant.**BTL 1 The rate at which solar energy arrives at the top of the atmosphere is called solar constant Isc. It is defined as the amount of energy received in unit time for unit area perpendicular to the suns direction of the mean distance of the earth from the sun.
2.	**What is the use of pyranometer?**BTL 2 A Pyranometer is designed to measure global radiation, usually on a horizontal surface, but can also be used on an inclined surface. When shaded from beam radiation by using a shading ring, a pyanometer measures diffused radiation.
3.	**What is the function of pyrheliometer?**BTL 2 An instrument that measures beam radiation by using a long narrow tube to collect only beam radiation from the sun at normal incidence.
4.	**Define Heat Removal factor(F_R). May 2009** BTL 1 Heat Removal factor(F_R) is defined as the ratio of actual useful energy collected to the useful energy collected if the entire collector absorber surface were at the temperature of the fluid entering the collector.Heat Removal factor(F_R) = Actual useful energy collected/ Useful energy collected if the entire collector absorber surface were at the temperature of the fluid entering the collector.
5.	**What is diffusion radiation?**BTL 2 The radiation received on a terrestrial surface scattered by aerosals and dust from all parts of the sky dome is known as diffuse radiation.
6.	**Define solar insolation.** BTL 1 The sum of beam and diffusion radiation is referred to as total radiation. Total radiation when measured at a location on the earth's surface it is called solar insulation at the place. .
7.	**Define Albedo of earth.** BTL 1 The earth reflects back nearly 30% pf the total solar radiant energy to the space by reflection from clouds, by scattering and by reflection at the earth's surface. This is called the albedo of the earth's atmosphere.
8.	**List different solar technologies.**BTL 4 • Solar thermal technology • Photovoltaics technology(pv)

	• Photosynthetic and chemical processes.
9.	**Define performance rating of solar thermal systems.** BTL 1 The solar thermal systems performance rating is an analytically derived set numbers representing the characteristics all-day energy output of the solar thermal systems under standard rating conditions, measured in Btu per square foot per day.(Btu/ft2/day).
10	**Define solar collector efficiency.**BTL 1 Collector efficiency is defined as the ration of the energy actually absorbed and transferred to the heat- transport fluid by the collector (useful energy) to the energy incident on the collector.
11	**What are the advantages of an Air collector over a liquid solar collector?**BTL 2 • It is compact in construction and requires little maintenance. • The need to transfer thermal energy from the working fluid to another fluid is eliminated as air is used directly as the working fluid. • Corrosion is completely eliminated.
12	**What are the advantages of PV technology?**BTL 2 • Reliability • Durability • Low maintenance cost • No fuel cost • Safety
13	**What is photovoltaic effect? (June 2008)** BTL 2 The phenomenon in which the incidence of light or other electromagnetic radiation upon the function of two dissimilar materials, as a metal and a semiconductor induces the generation of an electro motive force.
14	**Define solar cell efficiency?**BTL 1 The efficiency of a solar cell is the ration of the electrical power it delivers to the load, to the optical power incident on the cell.
15	**What is grid connected PV system?**BTL 2 In a grid connected system, the grid acts as a backup and there is no need for battery storage unless there is a power outage problem. This makes grid connected PV systems relatively small.
16	**What are the applications of solar thermal technologies?**BTL 2 • Solar water heater • Solar industrial heating system • Solar refrigeration systems • Solar air- conditioning systems

	• Solar cookers • Solar furnaces
17	**What are the different losses occurs during performance calculation of collector efficiency?** BTL 2 • Conductive losses • Convective losses • Radiation losses
18	**What is shadow factor?**BTL 2 Shadow factor= surface of the collector receiving light/ total surface of the collector.
19	**What is cosine loss factor?**BTL 2 For maximum power collection, the surface of collector should receive the sunrays perpendicularly. If the angle between the perpendicular to the collector surface and the direction of sunray is θ, the area of solar beam intercepted by the collector surface is proportional to cos θ.
20	**What is helicostats? (May 2010)** BTL 1 'Helicostats' are large, flat reflecting mirrors with a provision to track the sun in two planes. The solar rays are reflected by each individual heliostat on the central receiver mounted on a fall tower.
21	**State Wien's Law.**BTL 1 Wien's Law states that, the emission increases with temperature. The re-emitted light is so progressively shorter wavelength and greater energy as the temperature of blackbody increases. This is expressed by Wien's Law, which can be written as, $\lambda_{max} T$ = Constant = 2989μm Kelvin where, λ—wavelength T—Temperature of the black surface in K.
22	**State Planck's Law.Apr/May 2008**BTL 1 Planck's Law states that the spectral emissive power of a black surface is given by $$e_{b\lambda} = \frac{2\pi C_1}{\lambda^5\left[\exp(C_2/\lambda T)-1\right]}$$ Where, C_1 and C_2 are constants whose values are 0.596x10^{-16} M-m^2 and 0.014387m-K respectively, λ—wavelength and T—Temperature of the black surface in K.
23	**State Stefan- Boltzmann Law.**BTL 1 The Stefan- Boltzmann Law is obtained by integrating Planck's law overall the wavelengths from 0 to ∞ and states that the emissive power of a black surface is given by $e_b = \sigma T^4$

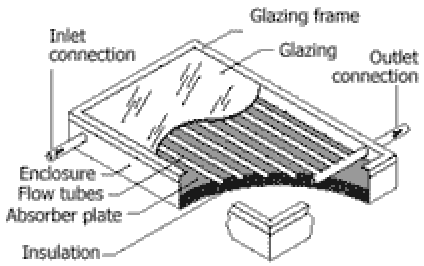
	Where, T—Temperature of the black surface in K σ -- constant called the Stefan- Boltzmann constant = 5.670x10^{-18}W/m^2-K^4.
24	**Define Fin Eficiency.**BTL 1 Fin Eficiency is used to indicate the effectiveness of a fin in transferring a given quantity of heat. Fin efficiency is defined as, Fin Eficiency = $\frac{Actual\,heat\,transfered}{Heat\,which\,would\,be\,transfered\,if\,entire\,fin\,area\,were\,at\,base\,temperature.}$
25	**State Snell's law. (Dec 2011)** BTL 1 The incident and refracted beams are related to each other by Snell's law which states that, $$\frac{Sin\theta_1}{Sin\theta_2}=\frac{n_2}{n_1}$$ Where, θ_1= angle of incidence θ_2 = angle of refraction n_1, n_2 = refractive indices of the two medium.
PART * B	
1.	**With the help of neat diagram explain solar applications in detail.(13M)** BTL 2 **1. Solar water heaters 2. Solar Distillation 3. Solar Pumping Systems 4. Solar Cooker** **5. Solar greenhouse.** Answer page : 6.75 – V.Thiyagarajan • Solar water heater(4M) 

	• Solar distillation (4M) Solar distillation is the use of solar energy to evaporate water and collect its condensate within the same closed system. Unlike other forms of water purification it can turn salt or brackish water into fresh drinking water (i.e. desalination). The structure that houses the process is known as a solar still and although the size, dimensions, materials, and configuration are varied, all rely on the simple procedure wherein an influent solution enters the system and the more volatile solvents leave in the effluent leaving behind the salty solute behind. • **Solar pumping system**: (5M)Asolar-powered pump is a pump running on electricity generated by photovoltaic panels or the radiated thermal energy available from collected sunlight as opposed to grid electricity or diesel run water pumps. The operation of solar powered pumps is more economical mainly due to the lower operation and maintenance costs and has less environmental impact than pumps powered by an internal combustion engine (ICE). Solar pumps are useful where grid electricity is unavailable and alternative sources (in particular wind) do not provide sufficient energy.
2.	**Explain briefly about concentrating type of solar collectors. 13M (BTL 2)** Answer page : 6.62 – V.Thiyagarajan • Types & explanation (13M) 1. Modified flat plate collector 2. Parabolic collector 3. Cylindrical parabolic collector 4. Fixed mirror solar concentrator 

3. **What are the main components of a flat plate solar collector, explain the functions of each. (13 M)(Apr/May 2015).** BTL 2

Answer page : 6.48 – V.Thiyagarajan

- Diagram (6M)



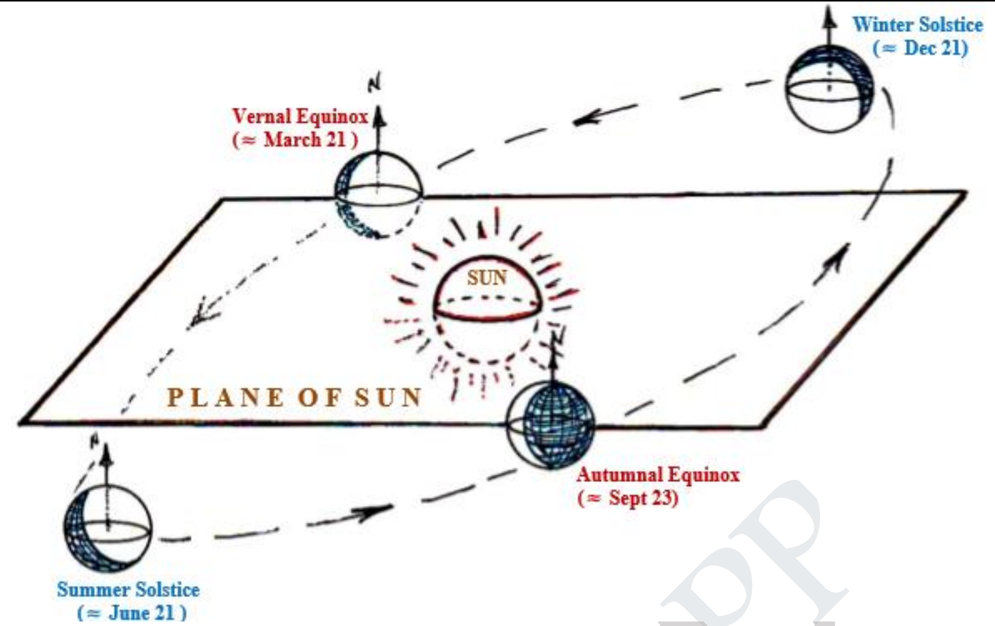
- **Working (4M)**
- A typical flat-plate collector is a metal box with a glass or plastic cover (called glazing) on top and a dark-colored absorber plate on the bottom. The sides and bottom of the collector are usually insulated to minimize heat loss.
- Sunlight passes through the glazing and strikes the absorber plate, which heats up, changing solar energy into heat energy. The heat is transferred to liquid passing through pipes attached to the absorber plate. Absorber plates are commonly painted with "selective coatings," which absorb and retain heat better than ordinary black paint. Absorber plates are usually made of metal—typically copper or aluminum—because the metal is a good heat conductor. Copper is more expensive, but is a better conductor and less prone to corrosion than aluminum. In locations with average available solar energy, flat plate collectors are sized approximately one-half- to one-square foot per gallon of one-day's hot water use.
- **Applications (3M)**
  1. The main use of this technology is in residential buildings where the demand for hot water has a large impact on energy bills. This generally means a situation with a large family, or a situation in which the hot water demand is excessive due to frequent laundry washing.
  2. Commercial applications include laundromats, car washes, military laundry facilities and eating establishments. The technology can also be used for space heating if the building is located off-grid or if utility power is subject to frequent outages. Solar water heating systems are most likely to be cost effective for facilities with water heating systems that are expensive to operate, or with operations such as laundries or kitchens that require large quantities of hot water.

4. **How solar energy be converted into electrical energy? Describe the elements of such a plant in detail.(13M)**BTL 4

Answer page : 6.44- V.Thiyagarajan

- **Principle of conversion (Radiant- to – heat) (4M):**
  1. The principle of conversion of solar radiation to heat energy is very simple. Whenever an object is exposed to sunlight, it reflects some radiation, it transmits some radiation and it absorbs some radiation.

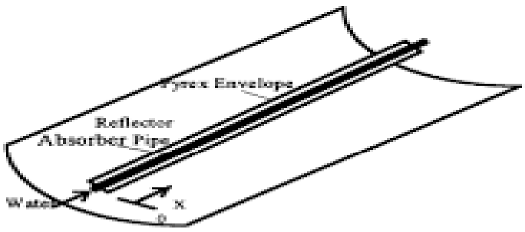
	2. The solar energy that object absorbs gets converted into heat energy. • Absorption, Emission & Transmission(6M) 1. If radiation incidence on material a certain part of the radiation is absorbed. A body's capacity to absorb radiation is called absorption. 2. The emission represents the power radiated by a body. The relationship between absorption α and emission Ɛ is defined by "kirchhoffs law". 3. In addition with absorption and emission, also reflection and transmission play a role. The reflection coefficient ρ describes the ratio of the reflected transmitted through a given material to the entire radiation incident. 4. The sum of absorption, reflection & transmission id one $\alpha + \rho + \tau = 1$ • **Elements of solar power plant :** (3M) 1. Solar panels 2. Solar array mounting racks 3. Inverter 4. Battery pack 5. Backup generator 6. Charge controller
5.	**i) Define solar radiation. Explain the types of radiation in detail.(8M)**BTL 2 Answer page : 6.4- V.Thiyagarajan • The Energy produced and radiated by the sun is called solar energy. Energy is radiated by the sun as electromagnetic waves of which 99% have wavelength in the range of 0.2 to 4.0 micrometers. • The energy from the sun reaching the top of earth's atmosphere consists of about 8 % ultraviolet radiation (short wavelength, less than 0.39 micrometer), 46 % visible light (0.39 to 0.78 micrometer) & 46 % infrared radiation. • Types: 1. Direct radiation 2. Indirect 3. Reflected 4. Global radiation **ii) Write short notes on solar radiation geometry.(7M) (Apr 2017)**BTL 2 Answer page : 6.16- V.Thiyagarajan • The Earth's daily rotation about the axis through its two celestial poles (North and South) is perpendicular to the equator, but it is not perpendicular to the plane of the Earth's orbit. In fact, the measure of tilt or obliquity of the Earth's axis to a line perpendicular to the plane of its orbit is currently about 23.5°. • We call the plane parallel to the Earth's celestial equator and through the center of the sun the plane of the Sun. • The Earth passes alternately above and below this plane making one complete elliptic cycle every year.

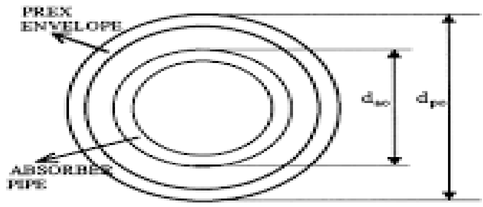


6.

Explain the performance analysis of cylindrical parabolic concentrating collector on detail. (13M) (Apr/May 2014) BTL 3

- Circuit diagram & explanation (7M & 6M):
- Consider the performance analysis of a cylindrical parabolic concentrating collector whose concentrator has an aperature 'W', length 'L' and rim angle 'ϕr', The absorber tube has an inner diameter 'Di' and an outer diameter 'D0' and it has concentric glass cover of inner diameter 'Dci' and outer diameter 'Dco' around it. The fluid being heated in the collector has mass flow rate 'm', a specific heat 'Cp', an inlet temperature 'Tfi' and an outlet temperature 'Tfo'.
- The analysis which follows is in many similar to the analysis of a liquid flat plate collectors. An energy balance on an elementary slice '*dx*' of the absorber tube, at a distance '*x*' from the inlet, yields the following equation for a steady state:





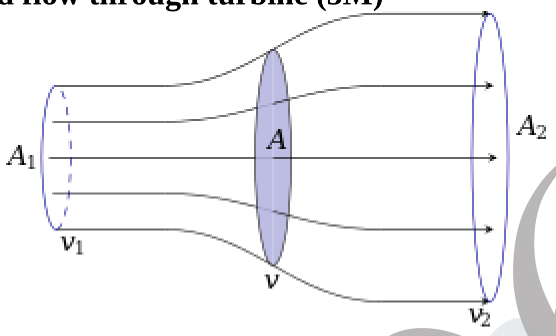
7	**Define the terms (i) Altitude angle. (ii) Incident angle, (ii) Zenith angle, (iv) Solar azimuth angle, (v) Declination angle and (vi) Hour angle.(13M)**BTL 1 Answer page : 6.92- V.Thiyagarajan • **Solar zenith angle(2M)**: The solar zenith angle is the angle between the zenith and the centre of the Sun's disc. The solar elevation angle is the altitude of the Sun, the angle between the horizon and the center of the Sun's disc. Since these two angles are complementary, the cosine of either one of them equals the sine of the other. • **Altitude angle(2M):** The Earth is tilted at an angle of 23.5 degrees with respect to the plane of the solar system. Hence, the sun is not always directly overhead at the equator. When the sun is directly overhead, the solar altitude is 90 degrees. This occurs at the equator during the vernal and autumnal equinoxes. • **Incident angle (2M)**:As the angle between the sun and the absorbing surface changes, the intensity of light on the surface is reduced. When the surface is parallel to the sun's rays (making the angle from perpendicular to the surface 90°) the intensity of light falls to zero because the light does not strike the surface. • **Solar azimuth angle (2M):** Azimuth is the angle along the horizon, with zero degrees corresponding to North, and increasing in a clockwise fashion. Thus, 90 degrees is east, 180 degrees is south, and 270 degrees is west. Using these two angles, one can describe the apparent position of an object (such as the Sun at a given time). • **Declination angle(3M) :**The declination angle, denoted by δ, varies seasonally due to the tilt of the Earth on its axis of rotation and the rotation of the Earth around the sun. If the Earth were not tilted on its axis of rotation, the declination would always be 0°. However, the Earth is tilted by 23.45° and the declination angle varies plus or minus this amount. Only at the spring and fall equinoxes is the declination angle equal to 0°. • **Hour angle (2M):**The angle may be measured in degrees or in time, with $24^h = 360°$ exactly. In astronomy, hour angle is defined as the angular distance on the celestial sphere measured westward along the celestial equator from the meridian to the hour circle passing through a point.
8	**Calculate the solar time corresponding to 12:00 (IST or Indian standard time) at Pondicherry (π.92° N, 79.92° E) on 17 July. The standard meridian for IST is 82.5 E °. (13M)** BTL 4 Sol: For Indian standard time longtitude, Iu= 82.5° $B= 360(198-8_I)/ 364$ $= 115.7°$. ET= 9.87 sin (2 X 115.7) – 7.53 cos (115.7)- 1.5 sin(115.7) = -5.8 min $4(I_m-I_{local})= 4 (-82.5-(-79.92))$ = -10.32 min

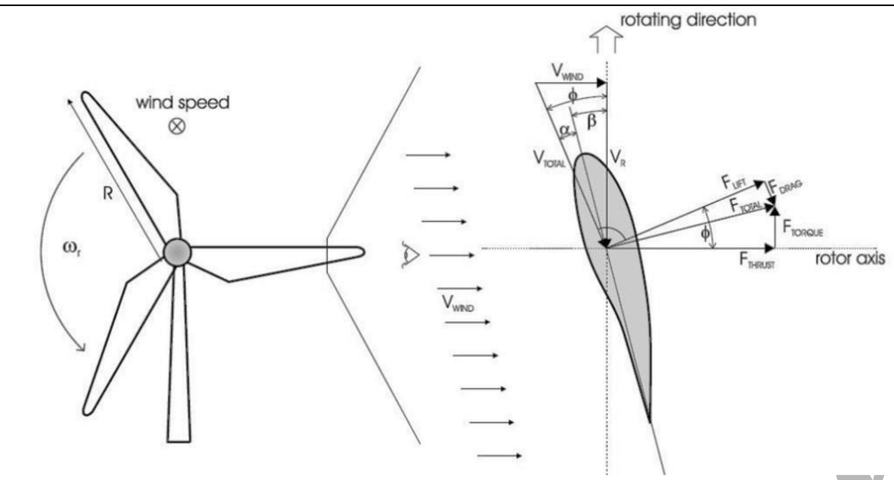
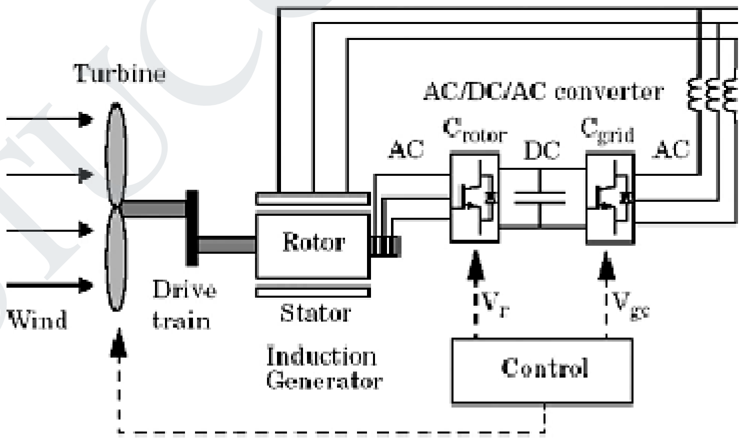
	Solar time = LST + ET+4(Im-I local) = 12:00 – 16.12 min = 11:44 h.

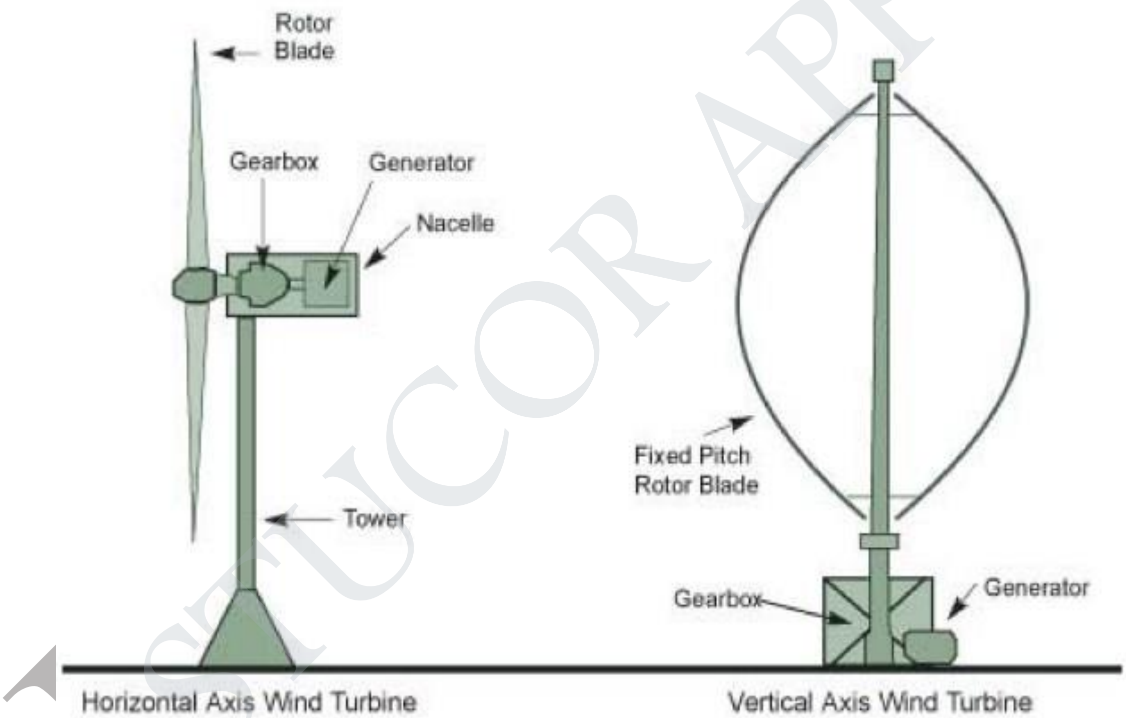
UNIT- V WIND ENERGY	
Introduction - basic principles of wind energy conversion - site selection considerations - basic components of a WECS (Wind Energy Conversion System) - Classification of WECS - types of wind Turbines - analysis of aerodynamic forces acting on the blade - performances of wind.	
PART * A	
Q.No	**Questions**
1.	**What is wind energy?**BTL 2 The kinetic energy of the wind due to its speed is captured by the turbine and its converted to mechanical energy. Along with the turbine, there is a generator present at the tower which is coupled to the wind turbine by a shaft and often with a gear box. The generator converts mechanical energy of turbine to electrical energy and its feeds of load point.
2.	**Mention the factors affecting the speed of wind?**BTL 2 The movement and speed of wind are affected by three main factors: • Pressure gradient • Rotation of the earth • Friction of the earth
3.	**List the types of winds?**BTL 2 • Global winds or planetary winds • Local winds • Trade winds • Westerlies • Polar winds • Periodic winds
4.	**How wind is measured?**BTL 4 The two most important things about the wind are its speed and direction in which it is belong. Wind speed is measured by the Beaufort scale wind socks or by special scientific instruments called anemometers. The unit of measurement is kilometers per hour(km/hr) or knots.
6.	**What is Nacelle?**BTL 2 The nacelle sits at top the tower and contains the gearbox, low and high speed shafts, generator, controller and brake.
7.	**What are the types of wind turbines?**BTL 2 Wind turbines are usually classified into two categories, according to the orientation of the axis of rotation with respect to the direction of wind. • Vertical axis wind tunes • Horizontal axis wind turbines
8.	**Mention the advantages of horizontal axis wind turbines?**BTL 2 • Higher efficiency • Ability to turn the blades • Lower cost to power ratio.

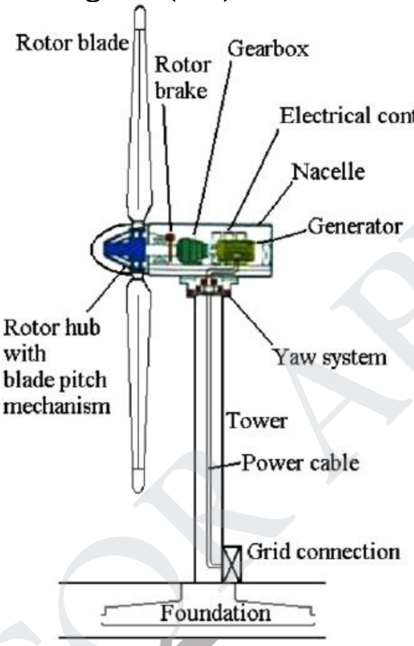
9.	**What is yaw control? Apr 2013** BTL 2 Adjusting the nacelle about the vertical axis to bring the rotar facing the wind is known as yaw control. The yaw control system continuously orients the rotor in the direction of wind.
10	**List the application of wind energy systems.**BTL 4 • Water pumping • Domestic use at remote communities • Farn and ranch • Wind mill for grinding, etc.
11	**Define machine capacity factor.**BTL 1 Machine capacity factor is defined as the ratio of average power output of a turbine during a month or a year to the rated power output.
12	**Define capacity utilization factor.**BTL 1 CUF= Annual energy generated/ theoretical energy generated
13	**List the application of wind energy.**BTL 4 • Water pumping wind mills • Water heaters • Wind assisted gas- turbine generating mills • Heating in industrial processes.
14	**Mention the sites suitable to install wind mills.**BTL 2 • Plane sites • Hill top sites • Sea shore sites • Off- shore shallow water sites
15	**What is the function of flywheel?** BTL 2 A flywheel used in machine serves as a reservoir which stores energy during the period when the supply of energy is more than the requirement and releases it during the period when the requirement of energy is more than the supply.
16	**Define performance coefficient related to wind turbine?**BTL 1 The coefficient of performance (Kp) is a functions of tip speed ratio which is normally used to classify rotor. Kp= Power delivered by the rotor/ Maximum power available in the wind Kp does not exceed 0.593 for horizontal axis wind machine.
17	**Write down the formula for tip speed ratio?**BTL 3

	Tip speed ratio = 0.052* rotor diameter* Rotation speed * wind speed
18	**What is tip speed ratio?**BTL 2 It is defined as the ratio of the speed of the blade tip of a windmill rotor to the speed of the free wind. This is a measure to know the growing ratio of the rotor.
19	**State the characteristics of lift and drag?**BTL 1 • Drag is in the direction of airflow • Lift is perpendicular to the direction of airflow • Generation of lift always causes a certain amount of drag to be developed with good aerofoil. • The lift produced can be 30 times greater than the drag.
20	**Define Solidity.**BTL 1 Solidity is defined as the percentage of the circumference of the rotor which contains material instead of air.
21	**What are the conversion losses available in wind energy conversion system?**BTL 2 A 100% efficient aerogenerator would be able to convert upto a maximum 60% of the available energy in wind into mechanical energy. Well- designed blades will typically extract 70% of the theoretical maximum, but losses incurred in the gearbox, transmission system and generator or pump could decrease overall wind turbine efficiency to 35% or less.
22	**Give the expression for available wind power.**BTL 3 Available wind power $P = \frac{1}{8}\rho\pi D^2 V^3 \ (watts)$ Where, ρ—Density of Air (ρ= 1.225kg/m^3 at sea level) D – Circular Diameter in horizontal axis aeroturbines. V—Velocity of Air
23	**Write down the condition for maximum power generation in wind energy conversion system.**BTL 2 The condition for maximum power generation in wind energy conversion system is given by $\frac{dP}{dV_e} = 0, \quad where \ P = \frac{1}{4g_c}\rho A(V_i + V_e)(V_i^2 - V_e^2)$ $3V_e^2 + 2V_iV_e - V_i = 0$, Solving the above quadratic equation we get $V_e = V_i$ and $V_e = \frac{1}{3}V_i$, only the second solution is physically acceptable. Thus, $V_{e\ opt} = \frac{1}{3}V_i$
24	**Define Magnus Effect.**BTL 1 Magnus Effect caused by spinning a cylinder in an air stream at the high speed of rotation. The spinning slow down the air speed on the side where the cylinder is moving into wind and increases it on the other side, the result is similar to an airfoil. This principal has been put to practical use in one or two cases but it is not generally employed.

PART * B	
1.	**Derive the expression for power developed due to wind.(13M)**BTL 3 Answer Page: 7.36 – V.Thiyagarajan • **Representation of wind flow through turbine (5M)**  • Wind turbines extract energy from wind stream by converting the kinetic energy of the wind to rotational motion required to operate an electric generator. • **Application of conservation of mass (continuity equation(8M):** Applying conservation of mass to this control volume, the mass flow rate (the mass of fluid flowing per unit time) is given by: $\dot{m} = \rho A_1 v_1 = \rho S v = \rho A_2 v_2$ • Where v_1 is the speed in the front of the rotor and v_2 is the speed downstream of the rotor, and v is the speed at the fluid power device. ρ is the fluid density, and the area of the turbine is given by S and A_1 are the area of the fluid before and after reaching the turbine. • So the density times the area and speed should be equal in each of the three regions, before, while going through the turbine and afterwards. • The force exerted on the wind by the rotor is the mass of air multiplied by its acceleration. In terms of the density, surface area and velocities, this can be written: $F = m a$ $= m \frac{dv}{dt}$ $= \dot{m} \Delta v$ $= \rho S v (v_1 - v_2)$
2.	**Explain the analysis of aerodynamic forces acting on the blade in wind energy. (13M)** BTL 2 Answer Page: 7.28 – V.Thiyagarajan • **Aero dynamic wind energy diagram & Explanation (6M& 7M)**

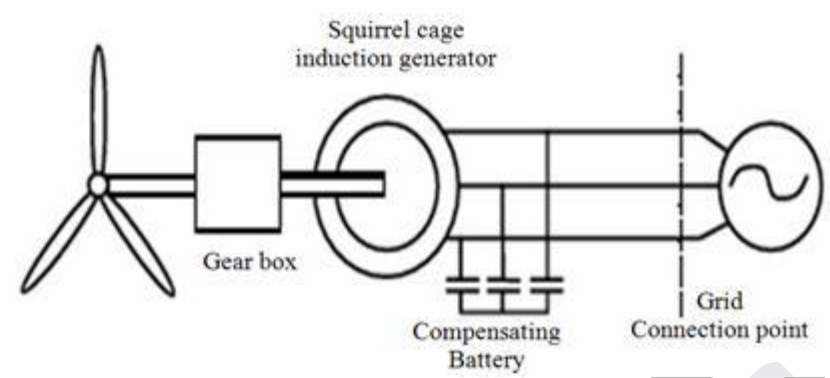
	 • Lift - which acts perpendicular to the flow • Drag- which operates is the direction of flow • Pitch : The blades of a rotor are curved so they can deflect the wind to create lift. The created lift force causes the rotor to rotate. • Solidity: The greater the solidity of a rotor due to presence of multiple blades, the slower it needs to interrupt the wind with the help of rotation.
3.	**i) Describe with a neat sketch the working of a wind energy system (WECS) with main components.(10M) (Apr 2017)**BTL 4 Answer Page: 7.46 – V.Thiyagarajan • Basic components of wind power system (5M)& Explanation (5M)  • The most modern generations of windmills are more properly called wind turbines, or wind generators, and are primarily used to generate electricity and electrical energy. Modern windmills are designed to convert the energy of the wind into electricity. The largest wind turbines can generate up to 6MW of power (for comparison a modern fossil fuel power plant generates between 500 and 1,300MW). • With increasing environmental concern, and approaching limits to fossil fuel consumption, wind power has regained interest as a renewable energy source. It is increasingly becoming more useful and sufficient in providing energy for many areas of the world,

	especially in temperate climates. **ii) Give some important factors that are considered for site selection of WECS.(3M)** BTL 4 • How good is the wind resource on the site? • Is the geography suitable to build wind farm? • How about the traffic conditions? • Power grid access condition • Considering the meteorological disaster
4.	**With the help of neat diagrams explain in detail about the construction and the working principle of different vertical axis wind turbines.(13M)(Apr/May 2017)**BTL 2 Answer Page: 7.60 – V.Thiyagarajan • Vertical axis wind turbine (Darrieus rotor) (5M)  • Components & working (6M): 1. Tower / rotor shaft 2. Blades 3. Support structure • Advantages & disadvantages of VAWT (2M): Adv: **1.** It can accept wind from any direction, eliminating the need of yaw control. **2.** Simple blade design and low cost of fabrication. **Dis-adv:**

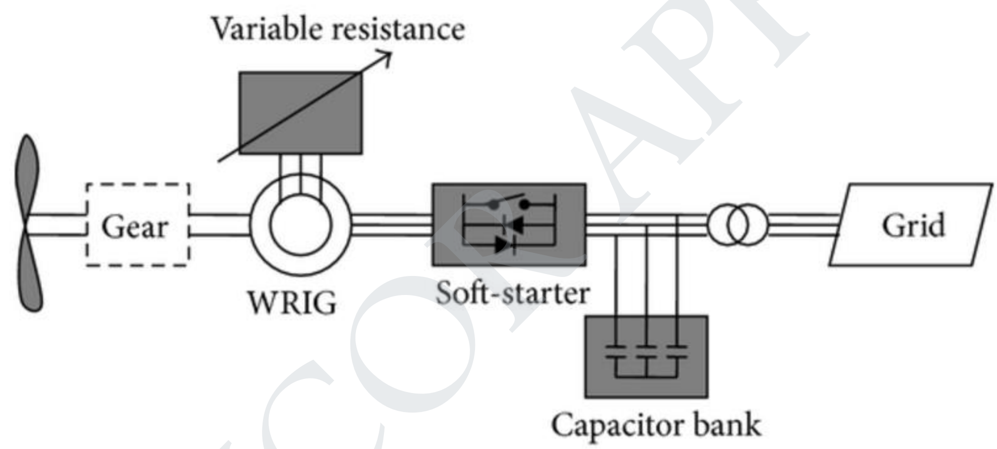
	1. Not self-starting, thus require generator to run in motor mode at start **2.** Lower efficiency.
5.	**With the help of neat diagrams explain in detail about the construction and the working principle of different horizontal axis wind turbines. (13M)(Apr/May 2017)**BTL 2 Answer Page: 7.63 – V.Thiyagarajan • **Horizontal axis wind turbine diagram (5M)**  • **Components & Working (8M)** 1. Horizontal-axis wind turbines (**HAWT**) have the main rotor shaft and electrical generator at the top of a tower, and may be pointed into or out of the wind. Small turbines are pointed by a simple wind vane, while large turbines generally use a **wind** sensor coupled with a servo motor. Most have a gearbox, which turns the slow rotation of the blades into a quicker rotation that is more suitable to drive an electrical generator. 2. Blades: The lifting style wind turbine blade. These are the most efficiently designed, especially for capturing energy of strong, fast winds. Some European companies actually manufacture a single blade turbine. 3. The r**otor** is designed aerodynamically to capture the maximum surface area of wind in order to spin the most ergonomically. The blades are lightweight, durable and corrosion-resistant material. The best materials are composites of fiberglass and reinforced plastic **4.** A gear boxmagnifies or amplifies the energy output of the rotor. The **gear box** is situated directly between the rotor and the generator. A rotor rotates the generator (which is protected by a nacelle), as directed by the tail vane.
6.	**Explain about wind generators and the classification of wind generators for wind power generation.(13M)**BTL 2 Answer Page: 7.71 – V.Thiyagarajan • Features of various types of generators & explanation (4M) 1. DC generator 2. Synchronous generator

3. Induction generator

- Classification of generators for wind power generation & explanation (5M)
  1. Squirrel cage induction generator(SCIG)



  2. Wound rotor induction generator(WRIG)



- Classification on the basis of their excitement process (3M)
  1. Grid connected IG
  2. Self – excited IG

7.

i) Explain the major applications of wind power plant.(7M) BTL 2

Answer Page: 7.54 – V.Thiyagarajan

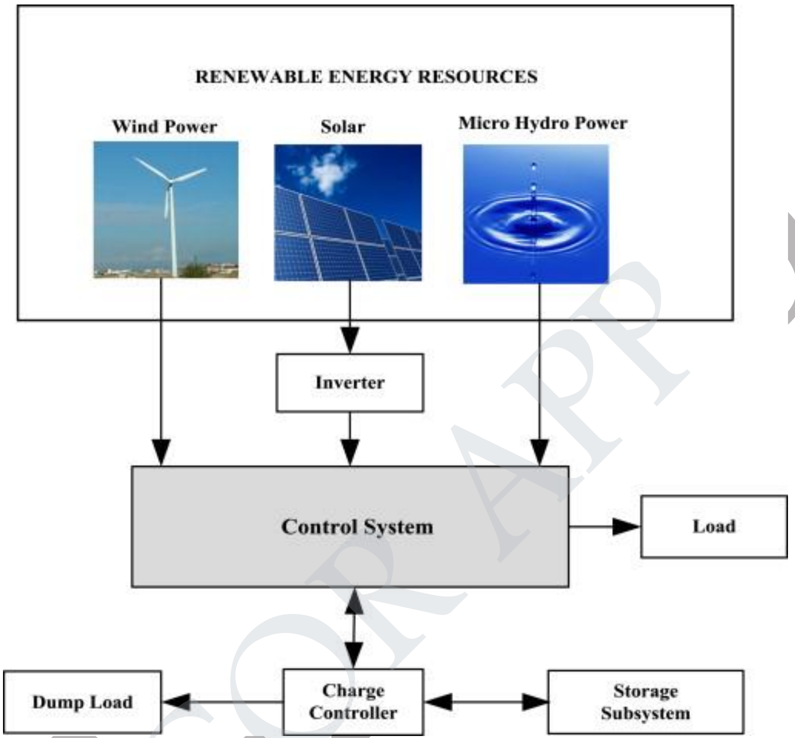
- **Wind farms:** A wind farm or wind park is a group of wind turbines in the same location used to produce electricity. A large wind farm may consist of several hundred individual wind turbines and cover an extended area of hundreds of square miles, but the land between the turbines may be used for agricultural or other purposes.
- **Grid connected wind power plants:** A grid-connected system allows you to power your home or small business with renewable energy during those periods (daily as well as seasonally) when the sun is shining, the water is running, or the wind is blowing. Any excess electricity you produce is fed back into the grid. When renewable resources are unavailable, electricity from the grid supplies your needs, eliminating the expense of electricity storage devices like batteries.
- **Wind power battery chargers**

ii) Explain the modes of wind power generation. (5M) BTL 2

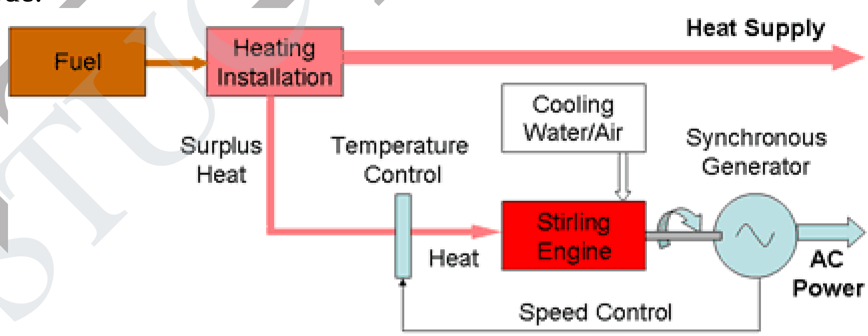
a. Standalone mode b. Back up mode

Answer Page: 7.90 & 7.91 – V.Thiyagarajan

- Standalone mode:



- Backup mode:



Combined Heat and Power (CHP)
Using Surplus or Waste Heat to Generate Electricity

Part *C

1 **Describe about constant/ variable speed operation of wind generator.(15M)** BTL 4

Answer page : 7.83- V.Thiyagarajan

- Block diagram of wind generator scheme , types & explanation (5M)
- Fixed speed drive (5M)

	1. One fixed speed drive 2. Two fixed speed drive • **Variable speed operation of wind generator**(5M) **1.** Variable speed-drive using power electronics **2.** Scherbius variable speed drive **3.** Variable speed direct drive.