SCHEME OF VALUATION

(Scoring Indicators)

Revision:2015 Course Code:6026 Course Title: MAINTENANCE ENGINEERING				
Qst No	Scoring Indicator	Split up score	Sub Total	Total
	Part A			
I (I)	5s, Autonomous maintenance, Kaizen, Planned maintenance, Quality maintenance, Training, Office TPM, Safety and health environment	Any 4points ½ mark each	$4x^1/_2=2$	2
I (2)	It is the ratio of the number of failures during particular unit interval to the average population during that interval. This failure rate is also known as hazard rate and instantaneous failure rate	1X2=2		2
I (3)	It is the mean time from one occurrence of an incident to the restoration of service. It is the inverse of the repair rate MTTR= Total Maintenance Time/ Number of Maintence Action	Def-2	2	2
I (4)	unbalance of rotating parts , Misalignment of couplings and bearings, Eccentric components, Bent shafts, Component looseness ,Worn or damaged gears ,Bad drive belts and drive chains, Bad anti-friction bearings, Torque variations ,Aerodynamic forces, Hydraulic forces , Rubbing	Any 4points ½ mark each	$4x^1/_2=2$	2
I (5)	It is the method of assessing machine condition by quantifying and examining wear particles suspended in the lubricant	2	2	2

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	Part B			
II (1)	Advantages 1. Cost effective in many capital intensive processes. 2. it detect problem at earlier stages 3. Increased component life cycle. 4. Energy savings. 5. Reduced equipment or process failure Disadvantages	3 points from each .Each carries 1 marks	1x6=6	6

	1. Catastrophic failures still likely to occur. 2. Includes performance of unneeded maintenance 3.It includes performance of unneeded maintenance 4.Labour intensive			
II (2)	Minimization of downtime, Improvement in availability of system, Extended life of equipment, Safety and smooth operation of the process, Provide adequate back up supply, Safety of the personal involved in the organization, Increased reliability of the system, Provide proper working environment.	Any 6 points. Each carries 1 marks	1x6=6	6
II (3)	The reliability of a system or device, is the probability that it will give satisfactory performance for a specified period of time under specified conditions Factors Product design, material quality, manufacturing process, testing and inspection, maintenance system, working environment, product complexity	Def-3 Factors-3	3+3	6
II (4)	**Unbalance** This is basically in reference to the rotating bodies. Unbalancing means the unequal forces in parts of a machine due to uneven distribution of masses. This kind of force generated from the rotary motion of the machine parts is the cause for vibration. A rotating mass or rotor is said to be out of balance when its center of mass is out of alignment with the Centre of rotation. Unbalance causes a moment which gives the rotor a wobbling movement characteristic of vibration of rotating structures **Effects of unbalance are** Noise Decreased life of bearings Unsafe working condition Reduced machine life Increased maintenance	Exp-6	6	6
II (5)	VIBRATION SIGNATURE It is the pattern of vibration generated during operation and plotted in the form of amplitude v/s frequency. Vibration signature provides a clear, accurate snapshot of the unique frequency components generated by or acting on a machine-train. Such a signature is obtained by converting time-domain data into its unique frequency components using a fast Fourier transform(FFT). Such a vibration signature referred to as frequency-domain data is used in signature analysis to evaluate the dynamics of the machine.	Exp-6	6	6
II (6)	1.It improves maintenance efficiency 2.It reduces maintenance cost and increases the life of	Any 6 points each	1x6=6	6

	equipment 3.It reduces the equipment downtime by proper scheduling 4.It reduces the overtime and ensures optimal utilization of manpower 5.It provides a historical database to assist in maintenance planning and budgeting 6.It provides maintenance reports in specific formats depending on the requirements 7.It access quickly to plant maintenance statistics..etc	carries 1 Marks		
II (7)	Fault Tree Analysis (FTA) is a systematic way of identifying all possible faults that could lead to system fail. FTA helps to identify and evaluate critical components, fault paths and possible errors. Fault trees are powerful design tools that can help to ensure that product performance objectives are met Event tree analysis An event tree is a visual representation of all events which can occur in a system. As the number of events increases, the picture will fan out similar to the branches of a tree. Event trees function similar to fault trees but in the opposite direction. An event tree attempts to enumerate a list of components and subsystems and determine the result of their Operation or non-operation.	Exp-3 marks for each	3+3=6	6

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	Part C			
III (a)	(1)Failure to replace worn out parts (2)Lack of lubrication (3)Neglected cooling (4)Indifference towards minor faults (5)Too high voltage (6)Too low voltage (7)Usage of wrong fuel (8)Neglected vibration etc	1 marks for each point	1x8=8	8

III (b)	(1)Job Distribution (2)Programme (3)Manpower Allocation (4)Planning Techniques (5)Planning Procedure (6)Estimation of Maintenance Works (7)Maintenance Control etc	1 marks for each point	1x7=7	7

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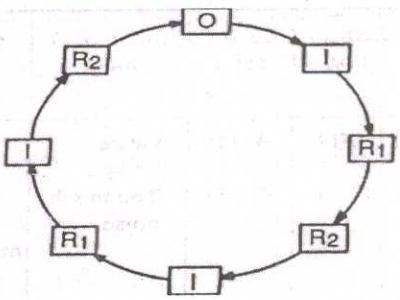
	Part C			
IV(a)	Repair Cycle The repeated performance of all/ some of the above mentioned activities in sequence between successive overhauling is termed as Repair cycle. To formulate a schedule, we may classify the maintenance work into the following activities 1. Inspection (I) 2. Minor Repair (R1) 3. Medium or major Repair (R2) 4. Overhauling (O)  From the point of overhauling Point (O), the activity is taken to be started in a clockwise direction. It is seen that at first an Inspection (I) is scheduled, then a minor (R1) and a major repair (R2) is planned. Inspection (I) is again done and a minor repair(R!) is performed. After the third inspection I) a major repairing (R2) takes place and then comes the time of next overhauling, completing one repair cycle. So the	Fig-4 Exp-4	3+5=8	8

	above typical repair cycle suggests to have three inspections, two minor and two major repairing in between the time span of two consecutive overhauling. This may simply be represented bas 01-I1-R11-R21-I2-R12-I3-R22-O2. Time period for a repair cycle is dependent on the time intervals in between two activities. If it is six months, then the time duration of above referred cycle is four years			
IV(b)	**Boundary lubrication** When a full fluid film is not developed between rubbing surfaces, the thickness of film may be reduced so that dry contact is formed at high points or asperities of mating surfaces. This condition is a characteristic of boundary lubrication. This situation arises when anyone of the full film thickness forming factors are missing. Example: starting and stopping in reciprocating Equipments, Compressor pistons, gear teeth contact etc. **Extreme Pressure Lubrication** Anti wear agents (chemicals) which are normally used in boundary lubrication will not be effective beyond certain temperature . In heavy loading applications, oil temperature raises beyond the anti wear protection. Under this situation lubricants containing additives that protect against extreme pressure called EP lubricants are used. EP lubrication can he achieved by chemical compounds of boron, phosphorus, sulphur, chloride or combination of these. These are activated by high temperature resulting from extreme pressure. At these temperatures EP molecules become reactive and release derivatives of phosphorus chloride or sulphur. These derivatives form a solid protective coating that fills the asperities of the exposed surfaces.	3.5 marks +3.5 Marks	3.5+3.5=7	7

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	Part C			
V(a)	R(t)=0.99, T=600 hrs		4+4=8	8

	$R(T)=e^{-\lambda t}$ $0.99=e^{-\lambda X600}$ $-0.0100=-600\lambda$ Failure rate (λ) = 1.67 X 10 -5 failurs/hr MTBF = $\frac{1}{\lambda}$ =59880.23 hrs	Eqn& Substitution=4 Answs=4		
V(b)	**Classification of Availability** 1. Inherent availability 2. Achieved availability 3. Operational availability **Inherent Availability** It is the probability that a system or equipment shall operate satisfactorily when used under prescribed conditions in an ideal support environment without any scheduled or preventive maintenance at any given time. Ideal support environment means the ready availability of tools, spare parts, manpower, manual etc. **Achieved Availability** It is the probability that a system or equipment shall operate satisfactorily when used under prescribed conditions in an ideal support environment with periodic preventive and corrective maintenance at any given time **Operational Availability** It is the probability that a system or equipment shall operate satisfactory when used under prescribed conditions in an actual supply environment without any scheduled or preventive maintenance at any given time	Clasf-1 Expl-2 Markseach	1+(2x3)	7

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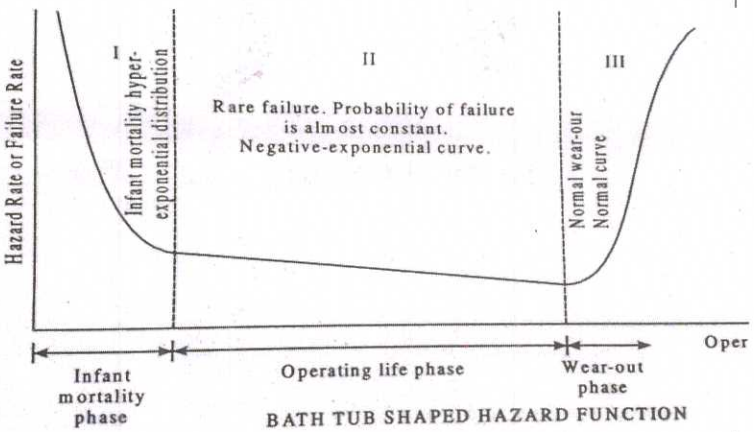
Qst No	Scoring Indicator	Split up score	Sub Total	Total
	Part C			
VI(a)	System Reliability=R(t)=1-(1-R1)(1-R2)(1-R3) = 1-(1-0.93)(1-0.95)(1-0.97) =0.99	Eqn, Subst=4 Answers=	4+4=8	8

	=99% Connected in Series = 0.93 x0.95 x 0.97 = 0.86 =86%	4		
VI(b)	**Bath Tub Curve (Failure Pattern of Equipment)** When the failure rate (number of failures per unit time) is plotted against a continuous time scale, the resulting chart is known as "bath tub curve" (because of its shape). This curve exhibits three distinct zones.  BATH TUB SHAPED HAZARD FUNCTION These are as follows : 1.Infant mortality period – This characterized by high failure rates. This high failure rate is due to non - alignment while shipping the product, misfit while manufacturing or assembly or very high initial friction between moving and mating parts. 2. The constant failure rate period- This phase is the operating phase, following this period the failure rate remains almost constant. Being generally constant during the normal life phase, the reliability curve corresponds to a negative exponential curve. 3. The wear out period In this phase, failure tend to increase rapidly due to gradual degradation of some property of the system essential to proper functioning, caused due to aging of the system.	Fig-4 Exp-3	4+3	7

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Qst No	Scoring Indicator	Split up score	Sub Total	Total
	Part C			
VII(a)	SHOCK PULSE METHOD (SPM) A method based on monitoring the mechanical impacts	Exp-8	8	8

	caused by bearing damage and operating condition problems is now available and widely used. This technique allows a bearing's condition to be tested over its entire life. It is not influenced by design, size, or background vibration of the machine. This technique is called the Shock Pulse Method (SPM). SPM used to analyse the vibration of bearing. SPM Method detects development of a mechanical shock wave caused by the impact between two masses. At the instantaneous moment of impact, molecular contact occurs and a compression (shock) wave develops in each mass. The SPM Method is based on the events occurring in the mass during the extremely short time period after the first particles of the colliding bodies come in contact. This time period is so short that no detectable deformation of the material has yet occurred. The molecular contact produces vastly increased particle acceleration at the impact point. SPM Instrument uses a piezo-electric accelerometer to measure the mechanical impact or shock pulse, without being influenced by other factors such as background vibration and noise.			
VII (b)	1.List the critical machines to be included for the analysis 2.Establish the acceptable level of machine vibration 3.Determine the normal vibration characteristics for each machine 4.Select, identify the periodic check points for all the machines under the analysis 5.Estimate the periodicity of vibration checks for the selected check points 6.Design a simple data recording and storing system 7.Develop an adequate data analysis procedure 8.Train the personnel to carry out the vibration monitoring and analysis	Procedure-7	7	7

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	Part C			
VIII (a)	**Frequency domain analysis** In frequency domain analysis, the vibration data is displayed or analysed as a function of frequency The time domain vibration signal is processed into frequency domain by applying a fast Fourier transform algorithm.	Def-2 Classi-1.5 Explan-4.5	=2+1.5+4.5=8	8

	Classification Signature spectrum Enveloped spectrum Band pass analysis **Signature Spectrum Analysis** Signature spectrum analysis takes the incoming signal and breaks it into its individual frequencies by using either an analogue filter or a software process called Fourier analysis. The frequency spectrum provides valuable information about the condition of machine **Enveloped Spectrum Analysis** Enveloped spectrum analysis technique is applied in condition monitoring when background vibrations have to be suppressed. Thus, it limits the monitoring to the appropriate frequency range. This technique involves first, a high-pass filtering operation to remove dominating low-frequency components in the spectrum. The resulting signal is then rectified partially or fully. **Band Pass Analysis** Band pass analysis involves filtering the vibration signal above or below specific frequencies in order to reduce the amount of information presented in the spectrum to set band of frequencies. They are classified into Broad band & Narrow band Broad band technique acquires overall or broad band vibration readings from select points on a machine.. Narrowband trending monitors the total energy for a specific bandwidth of vibration frequencies.			
VIII (b)	**Pistol Thermometers** Pistol thermometer is a non -contact, pistol-grip thermometer enables the capture of a simultaneous, time-stamped digital photographic image as a temperature reading is taken. The logged results and images can be uploaded via a USB connection to a PC using the windows-based software that comes with the thermometer. Thus, the temperatures can be stored, presented graphically and analysed. The photographic images can be displayed on screen for improved documentation and maintenance follow-up.Its temperature range is -30 to 900^0C. **Temperature tapes** This method is used for finding defects or defective items. Colour image will occur to tapes on response to temperature change A sticker having four of five 20 mm diameter dots	3.5 marks for each	3.5X2=7	7

	of special paints, each of which changes its colour at a particular temperature is stuck to the heat prone parts of the equipment. The operators or supervisor can identify its temperature range by looking at the stickers from a distance itself during their periodic patrol rounds.			

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	Part C			
IX(a)	Electrical Resistance Method Corrosion monitoring probes based on detecting and measuring changes in electrical resistance. These electrical resistance (ER) probes, some-times referred to as electronic coupons. This monitors the electrical resistance of a sensing element that is exposed to the environment of interest A probe which consists of a thin wire is inserted into the process fluid. As the wire corrodes, its cross-sectional area reduces and the electrical resistance increases. It can be measured with a suitable bridge circuit to give a continuous signal related to the rate of corrosion. ER probes are often selected because of their relatively simple operations, relatively low maintenance, ease of data interpretation, real-time data collection and reliability.	Exp-8	8	8
IX (b)	1. Forklilts require a daily inspection for proper operation. 2.Daily checks should include wheels, brakes, forks, chains, hydraulics, steering, horn, and fuel 3.Forklifts with engines should be checked for coolant and engine oil levels 4.Forks are subject to jolts, abrasion, overloading etc, which may reduce the thickness of blades, bend or twist, which should be carefully watched 5.Remove accumulations of grease and dirt 6.scheduled maintenance based on engine hour or motor hour experience may reduce malfunctions	1x7=7	7	7

	6.Give special attention to brakes, limit switches, trolley wheels, load hooks, cables and chains. 7.Inspect sheaves, nuts, bolts, braces, hooks and similar parts monthly or more frequently depending on usage			

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Qst No	Scoring Indicator	Split up score	Sub Total	Total
	Part C			
X(a)	Liquid Penetrant Test The liquid penetrant test is one of the oldest methods of non-destructive testing. In this test, the liquid, called penetrant, that is applied to the sample during testing in order to make any surface flaws more visible. Steps in liquid penetrant test Surface Preparation – pre cleaning and drying of test object Penetrant Application – applying liquid penetrant to be inspected Penetrant Dwell - permitting it to seep into surface discontinuities Excess Penetrant Removal - remove excess liquid from test surface Developer Application - applying developer to test surface to enhance indications Indication Development – indications formed by the application of developer Inspection - inspecting for penetrant indications Clean Surface - post cleaning to remove process residues	Def-2 procedure-6	2+6	8
X(b)	**Spectrometric oil analysis programme (SOAP)** Spectroscopy allows accurate, rapid measurements of many of the elements present in lubricating oil. It employs different methods to identify concentrations of particular elements within oil. These elements can be compared to as new sample for monitoring oil condition, monitoring presence of contaminants, additives & monitoring presence and rate of generation of metal particles. In atomic emission spectroscopy, through combustion of oil sample in a burner the metallic elements are atomized. A light beam is sent through the flame, and certain wavelengths will be extinguished due to absorption by the free atoms of the metals. Strength of	Exp-7	7	7

	each absorption dependence on the presence of particular elements and its concentration. This information can then be trended and used to identify components undergoing excessive wear conditions, particles size above 9 microns cannot be detected by this process and SOAP does not attempt to determine the specific failure modes of developing machine train problems. **Elements analyzed by SOAP** Iron, Chromium, Copper, Nickel, Aluminium, Silicon, Phosphorus Etc.			