

Master of Technology

in

**‘Industrial Tribology and Maintenance Engineering’
(Interdisciplinary Programme)**



**Industrial Tribology, Machine Dynamics
and Maintenance Engineering Centre (ITMMEC)**

**Indian Institute of Technology Delhi
HauzKhas, New Delhi – 110016
2015**

Master of Technology in ‘Industrial Tribology and Maintenance Engineering’ Interdisciplinary Programme

The overall credits structure

Category	PC	PE	OE	Total
Credits	33	09	06	48

Programme Core (PC)

ITL702	Diagnostic Maintenance and Condition Monitoring	3-0-2	4
ITL703	Fundamentals of Tribology	3-0-2	4
ITL705	Materials for Tribological Applications	3-0-0	3
ITL714	Failure Analysis and Repair	3-0-2	4
JID801	Major Project Part 1 (JIT)	0-0-12	6
JID802	Major Project Part 2 (JIT)	0-0-24	12
Total PC		12-0-42	33

Programme Electives (PE)

ITL709	Maintenance Planning and Control	3-0-0	3
ITL710	Design of Tribological Elements	3-0-0	3
ITL711	Reliability, Availability and Maintainability (RAM) Engineering	3-0-0	3
ITL717	Corrosion and its Control	3-0-0	3
ITL730	Lubricants	2-0-2	3
ITL740	Risk Analysis and Safety	2-1-0	3
ITL752	Bulk Materials Handling	2-0-2	3
ITL760	Noise Monitoring and Control	2-0-2	3
ITL810	Bearing Lubrication	3-0-0	3
JIS800	Independent Study	0-3-0	3
JID800	Minor Project	0-0-6	3

M. Tech. in Industrial Tribology and Maintenance Engineering

Sem.	Courses (Number, abbreviated title, L-T-P, credits)							Lec. Courses	Contact hrs. / week				Credits
									L	T	P	Total	
I	ITL03 Fundamentals of Tribology (3-0-2) 4	ITL705 Materials for Tribological Applications (3-0-0) 3				PE-1 (3-0-0) 3	OE-1 (3-0-0) 3	4	12	0	2	14	13
II	ITL702 Diagnostic Maintenance &Condition Monitoring (3-0-2) 4	ITL714 Failure Analysis &Repair (3-0-2) 4				PE-2 (3-0-0) 3	PE-3 (3-0-0) 3	4	12	0	4	16	14
III	JID801 Maj. Proj. Part 1 (JIT) (0-0-12) 6					OE-2 (3-0-0) 3		1	3	0	12	15	9
IV	JID802 Maj. Proj. Part 2 (JIT) (0-0-24) 12							0	0	0	24	24	12

Total = 48

COURSE TEMPLATE

1.	Department / Centre Proposing the course	ITMMEC
2.	Course Title (< 45 characters)	DIAGNOSTIC MAINTENANCE AND CONDITION MONITORING
3.	L-T-P structure	3-0-2
4.	Credits	4
5.	Course number	ITL702
6.	Status (category for program)	Core

7.	Pre-requisites (course no. / title)	Nil
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8.	Status-vis-à-vis other courses (give course number / title)	
8.1	Overlap with any UG / PG course of the Dept. / Centre)	No
8.2	Overlap with any UG / PG course of the other Dept. / Centre)	No
8.3	Supercedes any existing course	No

9.	Not allowed for (indicate program names)	NA
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10.	Frequency of offering	☐ Every Sem. ☐ 1 st Sem. ☒ 2 nd Sem. ☐ Either Sem.
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11.	Faculty who will teach the course Prof. NareshTandon Guest Faculty -	
12.	Will the course require any visiting faculty?	No
13.	Course objective (about 50 words) To impart knowledge about diagnostic maintenance and various techniques for condition monitoring of machines with applications.	
14.	Course contents (about 100 words) (include laboratory and design activities) Maintenance strategies and introduction to Condition Based Maintenance (CBM), Application and economic benefits, Signature analysis - online and off-line techniques, Various Condition Monitoring (CM) techniques - Vibration monitoring and analysis, Shock Pulse Method, Noise monitoring, Envelope detection technique, Cepstrum analysis, Oil analysis including wear debris and contaminant monitoring, Performance monitoring, Acoustic emission and other techniques, Non-destructive testing techniques, Temperature monitoring including Thermography, Application and choice of the method, Practical applications of diagnostic maintenance, Condition monitoring of mechanical and electrical machines, Case studies.	

15. Lectures Outline (with topics and number of lectures)

Module No.	Topic	No. of Hours
1.	Introduction	1
2.	Maintenance strategies CBM, economic benefits, different techniques	6
3.	Performance monitoring	2
4.	Vibration monitoring, Cepstrum and SPM	10
5.	Noise monitoring	3
6.	Acoustic emission monitoring	3
7.	Wear debris analysis	4
8.	Non destructive testing	7
9.	Temperature monitoring	2
10.	Condition monitoring of electrical machines	2
11.	Case studies	2
COURSE TOTAL (14 times 'L')		42

16. Brief description of tutorial activities

Module No.	Tutorial activity	No. of Hours

17. Brief description of laboratory activities

Module No.	Experiment description	No. of Hours
1.	Vibration monitoring of bearings & SPM	10
2.	Wear debris analysis – Ferrography, Particle counter	6
3.	Thermography and NDT	12
	Total	28

18. Suggested texts and reference materials:

1. Collacott, R.A., Mechanical fault diagnosis, Chapman & Hall, London; 1977.
2. B.K.N. Rao, Handbook of condition monitoring, Elsevier Advanced Technology, Oxford, 1996.
3. Thomson W.T., Theory of vibrations with applications, Prentice Hall, 1981.
4. Mix, P.E., Introduction to non-destructive testing, John Wiley & Sons, 2005.

19. Resources required for the course (itemized & student access requirements, if any)

19.1	Software	
19.2	Hardware	Yes
19.3	Teaching aides (videos, etc.)	
19.4	Laboratory	Yes
19.5	Equipment	Yes
19.6	Classroom infrastructure	Yes
19.7	Site visits	

20. Design contents of the course (Percent of student time with examples, if possible)

Date: 13/02/2015

(Signature of the Head of the Centre)

COURSE TEMPLATE

1.	Department / Centre Proposing the course	ITMMEC
2.	Course Title (< 45 characters)	FUNDAMENTALS OF TRIBOLOGY
3.	L-T-P structure	3-0-2
4.	Credits	4
5.	Course number	ITL703
6.	Status (category for program)	Core course

7.	Pre-requisites (course no. / title)	Nil
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8.	Status-vis-à-vis other courses (give course number / title)	
8.1	Overlap with any UG / PG course of the Dept. / Centre)	No
8.2	Overlap with any UG / PG course of the other Dept. / Centre)	No
8.3	Supercedes any existing course	

9.	Not allowed for -(indicate program names)	NA
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10.	Frequency of offering	☐ Every Sem. ☒ 1 st Sem. ☐ 2 nd Sem. ☐ Either Sem.
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11.	Faculty who will teach the course Prof. Jayashree Bijwe Guest Faculty -	
12.	Will the course require any visiting faculty?	No
13.	Course objective (about 50 words) To teach the students about the basics of mainly friction and wear. They would learn genesis of friction & wear, classification, factors influencing and controlling apart from basic laws governing them. While learning various types of friction and wear modes, emphasis will be given on mechanisms operative followed by some initial ways to control.	
14.	Course contents (about 100 words) (include laboratory and design activities) Introduction to tribology and its historical background. Factors influencing Tribological phenomena. Engineering surfaces – Surface characterization, Computation of surface parameters. Surface measurement techniques. Apparent and real area of contact. Contact of engineering surfaces- Hertzian and non-hertzian contact. Contact pressure and deformation in non-conformal contacts. Genesis of friction, friction in contacting rough surfaces, sliding and rolling friction, Various laws and theory of friction. Stick-slip friction behaviour, frictional heating and temperature rise. Friction measurement techniques. Wear and wear types. Mechanisms of wear - Adhesive, abrasive, corrosive, erosion, fatigue, fretting, etc., Wear of	

	metals and non-metals. Wear models - asperity contact, constant and variable wear rate, geometrical influence in wear models, wear damage. Wear in various mechanical components, wear controlling techniques. Introduction to lubrication. Lubrication regimes. Introduction to micro and nano-tribology.
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15. Lectures Outline (with topics and number of lectures)

Module No.	Topic	No. of Hours
1	Introduction to Tribology and its historical background ; factors influencing;	2
2	Engineering surfaces- characterization & techniques,	4
3	Apparent & real area of contact; contact of engineering surfaces-Hertzian and non-hertzian contacts; Contact pressure & deformation in non-conformal contacts	2
4	Genesis of friction, friction in contacting rough surfaces, sliding & rolling friction; various laws & theory of friction, Stick-slip friction behavior; frictional heating & temp. rise, Friction measurement techniques	14
5	Wear & wear types, mechanisms - Adhesive, abrasive, erosion, fatigue, fretting etc.	14
6	Wear of metals & non-metals, wear models-asperity contact, constant & variable wear rate, wear controlling techniques	2
7	Introduction to micro and nano-tribology	2
8	Lubrication, Lubrication regime.	2
COURSE TOTAL (14 times 'L')		42

16. Brief description of tutorial activities

Module No.	Tutorial activity	No. of Hours
		NIL

17. Brief description of laboratory activities

Module No.	Experiment description	No. of Hours
1	Introduction to experiments, some basic theoretical aspects, etc.	2
2	Surface characterization	2
3	Micro-hardness measurement	2
4	Friction and wear measurement of various materials in Adhesive, Abrasive, Erosive and reciprocating wear modes	12
5	Friction and wear measurement of brake-pad materials	4
6	Worn surface studies by SEM	2
7	Repeat turn and lab exam	
	Total	28

18. Suggested texts and reference materials:

- Tribology- Friction and wear of engineering materials; I. M. Hutchings, Butterworth-Heinemann, 1992.
- Engineering Tribology; G W Stachowiak and A W Batchelar, Butterworth-Heinemann, 2001.

- Introduction to Tribology; Bharat Bhushan, John and Wiley Sons, 2002.
- Friction Science & Technology: From concepts to application; Peter Blau, CRC Press, 2009.
- Tribology- A System Approach to the Science & Technology of Friction, Wear & Lubrication; H Czichos, Elsevier Scientific Pub. Co., 1978.

19. Resources required for the course (itemized & student access requirements, if any)

19.1	Software	
19.2	Hardware	Yes
19.3	Teaching aides (videos, etc.)	
19.4	Laboratory	Friction & wear labs, ITMMEC
19.5	Equipment	Tribometer, various available facilities in labs
19.6	Classroom infrastructure	Yes
19.7	Site visits	No

20. Design contents of the course (Percent of student time with examples, if possible)

Date: 13/02/2015

(Signature of the Head of the Centre)

COURSE TEMPLATE

1.	Department / Centre Proposing the course	ITMMEC
2.	Course Title (< 45 characters)	MATERIALS FOR TRIBOLOGICAL APPLICATIONS
3.	L-T-P structure	3-0-0
4.	Credits	3
5.	Course number	ITL 705
6.	Status (category for program)	Program Core

7.	Pre-requisites (course no. / title)	Nil
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8.	Status-vis-à-vis other courses (give course number / title)	
8.1	Overlap with any UG / PG course of the Dept. / Centre)	No
8.2	Overlap with any UG / PG course of the other Dept. / Centre)	AML 750
8.3	Supercedes any existing course	

9.	Not allowed for (indicate program names)	
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10.	Frequency of offering	☐ Every Sem. ☐ 1 st Sem. ☐ 2 nd Sem. ☐ Either Sem.
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11.	Faculty who will teach the course Dr. Deepak Kumar, Prof. Jayashree Bijwe Guest Faculty -	
12.	Will the course require any visiting faculty?	No
13.	Course objective (about 50 words) To understand the applicability of different materials for tribological applications. How do the surface and interface characteristics control the performance of tribological element and possible ways to surface protection/modification?	
14.	Course contents (about 100 words) (include laboratory and design activities) Introduction to tribological processes and tribological relevant properties of materials. An overview of engineering materials having potential for tribological application. Characterization and evaluation of Ferrous materials for tribological requirements/applications, Selection of ferrous materials for rolling element bearings, gears, crank shafts, piston rings, cylinder liners, etc. Non-ferrous materials and their applications such as sliding bearings, piston rings, cylinder liners, etc., materials for dry friction materials.	

	Composite materials (PM, CMC and MMC) for tribological applications. Surface treatment techniques with applications such as carburizing, nitriding, induction hardening, hard facing, laser surface treatments, etc. Surface coating techniques such as electrochemical depositions, anodizing, thermal spraying, Chemical Vapour Deposition (CVD), Physical Vapour Deposition (PVD), etc. and their applications. Lubricants- Introduction, requirements, types, Evaluation and testing of lubricants.
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15. Lectures Outline (with topics and number of lectures)

Module No.	Topic	No. of Hours
1.	Tribological processes, tribological properties and potential materials	4
2.	Ferrous materials and tribological elements	7
3.	Non-ferrous materials and tribological elements	7
4.	Materials for dry friction materials	5
5.	Composite materials for tribological applications.	5
6.	Surface treatment techniques and their applications	4
7.	Surface coating techniques and their applications	4
8.	Lubricants	6
COURSE TOTAL (14 times 'L')		42

16. Brief description of tutorial activities : NA

Module No.	Tutorial activity	No. of Hours

17. Brief description of laboratory activities : NA

Module No.	Experiment description	No. of Hours

18. Suggested texts and reference materials:

1. A.R. Landsdown and A.L. Price, 'Materials to Resist Wear', Pergamon Press 1986.
2. William A. Glaeser, 'Materials for Tribology' Tribology Series 20, Elsevier Science Publishers, 1992.
3. ASM Hand book Vol 5 Surface Engineering Materials, Park Ohio, ASM International 1994.
4. K.G. Bundinski, 'Surface Engineering for Wear Resistance', Englewood Cliffs, N.J. Prentice Hall, 1998.

19. Resources required for the course (itemized & student access requirements, if any)

19.1	Software	None
19.2	Hardware	None
19.3	Teaching aides (videos, etc.)	
19.4	Laboratory	None

19.5	Equipment	None
19.6	Classroom infrastructure	Projector
19.7	Site visits	None

20. Design contents of the course (Percent of student time with examples, if possible)

20.1	Design –type problems	20%
20.2	Open- ended problems	10%
20.3	Project- type activities	15%
20.4	Open ended laboratory work	
20.5	Others (Please specify)	

Date: 13/02/2015

(Signature of the Head of the Centre)

COURSE TEMPLATE

1.	Department / Centre Proposing the course	ITMMEC
2.	Course Title (< 45 characters)	MAINTENANCE PLANNING AND CONTROL
3.	L-T-P structure	3-0-0
4.	Credits	3
5.	Course number	ITL709
6.	Status (category for program)	Programme Elective

7.	Pre-requisites (course no. / title)	Nil
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8.	Status-vis-à-vis other courses (give course number / title)	
8.1	Overlap with any UG / PG course of the Dept. / Centre)	NA
8.2	Overlap with any UG / PG course of the other Dept. / Centre)	MEL866, SML844
8.3	Supercedes any existing course	NA

9.	Not allowed for (indicate program names)	NA
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10.	Frequency of offering	☐ Every Sem. ☐ 1 st Sem. ☐ 2 nd Sem. ☐ √ Either Sem.
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11.	Faculty who will teach the course Prof. O.P. Gandhi Guest Faculty -	
12.	Will the course require any visiting faculty?	No
13.	Course objective (about 50 words) Appreciation and application of maintenance, its concepts and strategies for industrial situations to undertake maintenance work in plants to meet the industry objective.	
14.	Course contents (about 100 words) (include laboratory and design activities) Objectives of planned maintenance, Maintenance philosophies, Preventive and Predictive maintenance, Emerging trends in maintenance-Proactive Maintenance, Reliability Centred Maintenance(RCM), Total Productive Maintenance (TPM), etc, Implementation of Maintenance strategy, Maintenance organization, Basis of planned maintenance system, Maintenance planning and scheduling, Maintenance control system and documentation. Spares and inventory planning, Manpower planning, maintenance auditing. Human factors in maintenance and training, maintenance costing, Maintenance performance. Repair decisions- Repair, replacement and overhaul, Computer applications in maintenance, Expert systems applications, maintenance effectiveness, Case studies.	

15. Lectures Outline (with topics and number of lectures)

Module No.	Topic	No. of Hours
1	Introduction to plant maintenance and objectives	2
2	Maintenance strategies / options, including their selection	5
3	Establishing Maintenance Plan and Schedule, including maintenance work order (MWO) and safety order	6
4.	Actions for Availability enhancement, reduction in downtime and maintenance cost	6
5	Maintenance work load, maintenance Control and documentation	4
6	Maintenance Performance / Effectiveness Analysis, including maintenance audit	4
7	Inspection, Replacement, and Overhaul and Repair Decisions	6
8	IT-aided maintenance management	3
9	Role of human in maintenance, likely errors and contributing factors	2
10	Design of systems based on maintenance	2
11	Case studies	2
COURSE TOTAL (14 times 'L')		42

16. Brief description of tutorial activities NOT APPLICABLE

Module No.	Tutorial activity	No. of Hours

17. Brief description of laboratory activities NOT APPLICABLE

Module No.	Experiment description	

18. Suggested texts and reference materials:

1. Kelly Anthony, "Maintenance planning and control", Affiliated East –West Press Pvt. Ltd., New Delhi, 1991.
2. Lindley R. Higgins, R. Keith Mobley and Darrin Wikoff, "Maintenance Engineering Handbook", The McGraw-Hill Companies, Inc., 2008.
3. Andrew K. S. Jardine and Albert H.C. Tsang, "Maintenance, Replacement and Reliability: Theory and Applications", CRC Press, 2013.

19. Resources required for the course (itemized & student access requirements, if any)

19.1	Software	√
19.2	Hardware	
19.3	Teaching aides (videos, etc.)	LCD
19.4	Laboratory	
19.5	Equipment	
19.6	Classroom infrastructure	
19.7	Site visits	√

20. Design contents of the course (Percent of student time with examples, if possible)

20.1	Design-type problems	10%
20.2	Open-ended problems	10%
20.3	Project-type activity	10%
20.4	Open-ended laboratory work	
20.5	Others (please specify)	

Date: 13/02/2015

(Signature of the Head of the Centre)

COURSE TEMPLATE

1.	Department / Centre Proposing the course	ITMMEC
2.	Course Title (< 45 characters)	DESIGN OF TRIBOLOGICAL ELEMENTS
3.	L-T-P structure	3-0-0
4.	Credits	3
5.	Course number	ITL 710
6.	Status (category for program)	Program Elective

7.	Pre-requisites (course no. / title)	
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8.	Status-vis-à-vis other courses (give course number / title)	
8.1	Overlap with any UG / PG course of the Dept. / Centre)	No
8.2	Overlap with any UG / PG course of the other Dept. / Centre)	MEL737, MEL748
8.3	Supercedes any existing course	

9.	Not allowed for (indicate program names)	
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10.	Frequency of offering	☐ Every Sem. ☐ 1 st Sem. ☐ 2 nd Sem. ☐ √Either Sem.
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11.	Faculty who will teach the course: Dr. Deepak Kumar Guest Faculty -	
12.	Will the course require any visiting faculty?	No
13.	Course objective (about 50 words) The course will introduce design of mechanical components based on tribological concepts.	
14.	Course contents (about 100 words) (include laboratory and design activities) Introduction-Tribological consideration in design, Conceptual design, Classification of tribological components, Mechanisms of tribological failures in machines, Zero wear concept, Computational techniques in design. Design of Dry Frictional Elements-Dry friction concepts, Brakes and Clutches, Friction belts and Dry rubbing bearing. Design of Fluid Frictional Elements- Fluid friction concepts, Design of hydrodynamically loaded journal bearings, externally pressurized bearings, Oscillating journal bearings, Externally pressurized bearings, Design of oil groove, Design of elliptical, multi-lobe and titled pad bearings.	

	Rolling elements bearings, Performance analysis of bearings, gears, seals, piston rings, machine tool slide ways, cams and follower and wire rope.
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15. Lectures Outline (with topics and number of lectures)

Module No.	Topic	No. of Hours
1.	Tribological consideration in design, Conceptual design, Classification of tribological components, Mechanisms of tribological failures in machines, Zero wear concept, Computational techniques in design.	14
2.	Design of Dry Frictional Elements-Dry friction concepts, Brakes and Clutches, Friction belts and Dry rubbing bearing.	10
3.	Design of Fluid Frictional Elements Fluid friction concepts, Design of hydrodynamically loaded journal bearings, externally pressurized bearings, Oscillating journal bearings, Externally pressurized bearings, Design of oil groove, Design of elliptical, multi-lobe and titled pad Bearings.	10
4.	Rolling elements bearings, Performance analysis of bearings, gears, seals, piston rings, machine tool slide ways, cams and follower and wire rope.	8
COURSE TOTAL (14 times 'L')		42

16. Brief description of tutorial activities: NA

Module No.	Tutorial activity	No. of Hours

17. Brief description of laboratory activities: NA

Module No.	Experiment description	

18. Suggested texts and reference materials:

1. D. Dowson, C.M. Taylor, M. Godet, D. Berthe, 'Tribological Design of Machine Elements', Elsevier B.V., 1989
- A. W. Batchelor and G. Stachowiak, 'Engineering Tribology', Butterworth-Heinemann, 2000.
2. T.A. Stolarski, 'Tribology in Machine Design', Butterworth-Heinemann, 1999.

19. Resources required for the course (itemized & student access requirements, if any)

19.1	Software	CAD, MATLAB
19.2	Hardware	None
19.3	Teaching aides (videos, etc.)	
19.4	Laboratory	
19.5	Equipment	
19.6	Classroom infrastructure	Projector
19.7	Site visits	None

20. Design contents of the course (Percent of student time with examples, if possible)

20.1	Design –type problems	25%
20.2	Open- ended problems	10%
20.3	Project- type activities	20%
20.4	Open ended laboratory work	
20.5	Others (Please specify)	

Date: 13/02/2015

(Signature of the Head of the Centre)

COURSE TEMPLATE

1.	Department / Centre Proposing the course	ITMMEC
2.	Course Title (< 45 characters)	RELIABILITY, AVAILABILITY AND MAINTAINABILITY (RAM) ENGINEERING
3.	L-T-P structure	3-0-0
4.	Credits	3
5.	Course number	ITL711
6.	Status (category for program)	Programme Elective

7.	Pre-requisites (course no. / title)	Nil
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8.	Status-vis-à-vis other courses (give course number / title)	
8.1	Overlap with any UG / PG course of the Dept. / Centre)	NA
8.2	Overlap with any UG / PG course of the other Dept. / Centre)	AML730, EEL799, MEL866, SML844
8.3	Supercedes any existing course	NA

9.	Not allowed for (indicate program names)	NA
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10.	Frequency of offering	☐ Every Sem. ☐ 1 st Sem. ☐ 2 nd Sem. ☐ √Either Sem.
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11.	Faculty who will teach the course Prof. O.P. Gandhi Guest Faculty -	
12.	Will the course require any visiting faculty?	No
13.	Course objective (about 50 words) Understanding and application of reliability, availability and maintainability concepts to systems / plant machinery.	
14.	Course contents (about 100 words) (include laboratory and design activities) System concepts in RAM Engineering, Fundamentals of reliability, Failure distributions, Statistical analysis of failure data, Weibull analysis, Monte Carlo simulation, System reliability assessment. Reliability of repairable and non-repairable systems. Point, mission and steady state availability. Availability assessment. Maintainability and its assessment. Design for reliability and maintainability', Practical applications of RAM Engineering to systems, products and processes	

15. Lectures Outline (with topics and number of lectures)

Module No.	Topic	No. of Hours
1	Introduction to RAM Engineering, and System concepts	3
2	Fundamentals of reliability and Failure distributions	6
3	Reliability assessment of components and systems	6
4	Availability and its assessment	4
5	Reliability and availability of repairable and non-repairable systems	5
6	Maintainability and its assessment	5
7	Failure, maintenance and repair data analysis, and data sources	3
8	Design for reliability and maintainability	8
9	Practical applications of RAM Engineering to systems, products and processes	2
COURSE TOTAL (14 times 'L')		42

16. Brief description of tutorial activities NOT APPLICABLE

Module No.	Tutorial activity	No. of Hours

17. Brief description of laboratory activities NOT APPLICABLE

Module No.	Experiment description	

18. Suggested texts and reference materials:

1. Ebeling Charles E., "An introduction to reliability and maintainability engineering", Tata McGraw-Hill Pub. Co., New Delhi, 2000.
2. Benjamin S. Blanchard, "Maintainability: A Key to Effective Serviceability and Maintenance Management", John Wiley & Sons, 1995.
3. B.S. Dhillion, "Engineering Maintainability: How to Design for Reliability and Easy Maintenance", Gulf Pub. Co., 1999.
4. L.S. Srinath, "Reliability Engineering", Affiliated East-West Press Pvt. Ltd., New Delhi, 2005.

19. Resources required for the course (itemized & student access requirements, if any)

19.1	Software	√
19.2	Hardware	
19.3	Teaching aides (videos, etc.)	LCD
19.4	Laboratory	
19.5	Equipment	
19.6	Classroom infrastructure	
19.7	Site visits	√

20. Design contents of the course (Percent of student time with examples, if possible)

20.1	Design-type problems	10%
20.2	Open-ended problems	10%
20.3	Project-type activity	10%
20.4	Open-ended laboratory work	
20.5	Others (please specify)	

Date: 13/02/2015

(Signature of the Head of the Centre)

COURSE TEMPLATE

1.	Department / Centre Proposing the course	ITMMEC
2.	Course Title (< 45 characters)	FAILURE ANALYSIS AND REPAIR
3.	L-T-P structure	3-0-2
4.	Credits	4
5.	Course number	ITL 714
6.	Status (category for program)	Program Core

7.	Pre-requisites (course no. / title)	Nil
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8.	Status-vis-à-vis other courses (give course number / title)	
8.1	Overlap with any UG / PG course of the Dept. / Centre)	No
8.2	Overlap with any UG / PG course of the other Dept. / Centre)	AML 852
8.3	Supercedes any existing course	
9.	Not allowed for (indicate program names)	

10.	Frequency of offering	☐ Every Sem. ☐ 1 st Sem. ☐ 2 nd Sem. ☐ Either Sem.
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11.	Faculty who will teach the course	Dr. Deepak Kumar, Prof. O.P. Gandhi
	Guest Faculty -	

12.	Will the course require any visiting faculty?	No
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13.	Course objective (about 50 words)
	Understanding of failure analysis concepts, techniques and procedures for plant machinery and components, and prevention of failures.

14.	Course contents (about 100 words) (include laboratory and design activities)
	Introduction, need for failure analysis, Classification of failures, Fundamental causes of failures, influence of type of loading (e.g. static, fatigue, shock, etc.) on nature of failures, Role of stress; processing and fabrication defects, Effect of residual stresses induced during fabrication processes, Influence of temperature and environment on failure, Crack and subsurface crack like defects and their significance in failure. Micro mechanisms of failures; Ductile and brittle fracture, Fracture initiation and propagation, Fatigue failures, Wear related failures, High temperature failures, low temperature failures, etc., Studies and analysis of failed surfaces. Identification of failures, Techniques of failure analysis, Microscopic methods, Fracture mechanics techniques, Prediction of failures, Residual life assessment and life extension, Typical case studies in failure analysis, Logical fault finding and its application, Inspection and safety measures, Repair techniques and economic considerations, Failure analysis for design

	improvement and proactive maintenance, Design for repairability, Case Studies.
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15. Lectures Outline (with topics and number of lectures)

Module No.	Topic	No. of Hours
1.	Introduction, need for failure analysis, Classification of failures	2
2.	Fundamental causes of failures, influence of type of loading on nature of failures	5
3.	Role of stress; processing and fabrication defects, Effect of residual stresses induced during fabrication processes.	3
4.	Influence of temperature and environment on failure	5
5.	Crack and subsurface crack like defects and their significance in failure.	4
6.	Micro-mechanisms of failure	6
7.	Identification of failures, Techniques of failure analysis	2
8.	Microscopic methods, Fracture mechanics techniques	3
9	Prediction of failures, Residual life assessment and life extension	3
10	Typical case studies in failure analysis	4
11.	Failure analysis for design improvement and proactive maintenance, Design for repairability, Case Studies	5
COURSE TOTAL (14 times 'L')		42

16. Brief description of tutorial activities: NA

Module No.	Tutorial activity	No. of Hours

17. Brief description of laboratory activities

Module No.	Experiment description	No of Hrs.
1.	To study the toughness or energy absorbing properties of various materials under Izod and Charpy Impact Tests.	2
2.	To obtain twisting moment-twist relationship of a mild steel specimen	2
3.	To study fatigue crack propagation study.	2
4.	Failure under creep	2
5.	Microstructural study of metallic alloys	2
6.	To study the fracture strength of glass before and after etching using Griffith theory.	2
7.	Wear surface study- Examination of wear mechanism, particles and contamination of a failed sample.	2
8.	Study of SEM and EDX system for fracture analysis.	4
9.	NDT examination of the failed sample.	2
10	Failed sample case study	8
	Total	28

18. Suggested texts and reference materials:

1. ASM handbook; Vol. 11, 'Failure analysis and prevention', eds. R.J. Shilpey and W.T. Becker, ASM International, 2002.
2. Arthur J. McEvily: Metal Failures, Mechanisms, Analysis Prevention, John Wiley & Sons Inc, New Jersey, USA, 2013.
3. Neville W. Sachs, P.E.: Practical Plant Failure Analysis, Taylor & Francis Group, 2007
4. Shin-Ichi Nishida, Failure Analysis in Engineering Applications, Nikkan Kogyo Shimbun Ltd. Tokyo, 1992
5. Marc Meyers and Krishan Chawla: Mechanical Behaviour of Materials, Cambridge University Press, 2009

19. Resources required for the course (itemized & student access requirements, if any)

19.1	Software	None
19.2	Hardware	Samples,
19.3	Teaching aides (videos, etc.)	
19.4	Laboratory	SEM, NDT, SOM, MTS, Materials Science
19.5	Equipment	
19.6	Classroom infrastructure	Projector
19.7	Site visits	None

20. Design contents of the course (Percent of student time with examples, if possible)

20.1	Design –type problems	20%
20.2	Open- ended problems	10%
20.3	Project- type activities	15%
20.4	Open ended laboratory work	
20.5	Others (Please specify)	

Date: 13/02/2015

(Signature of the Head of the Centre)

COURSE TEMPLATE

1.	Department / Centre Proposing the course	ITMMEC
2.	Course Title (< 45 characters)	CORROSION AND CONTROL
3.	L-T-P structure	3-0-0
4.	Credits	3
5.	Course number	ITL717
6.	Status (category for program)	Elective course

7.	Pre-requisites (course no. / title)	Nil
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8.	Status-vis-à-vis other courses (give course number / title)	
8.1	Overlap with any UG / PG course of the Dept. / Centre)	No
8.2	Overlap with any UG / PG course of the other Dept. / Centre)	No
8.3	Supercedes any existing course	

9.	Not allowed for -(indicate program names)	NA
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10.	Frequency of offering	Every Sem. ☒ 1 st Sem. ☐ 2 nd Sem. ☐ → Either Sem.
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11.	Faculty who will teach the course Prof. Jayashree Bijwe	
12.	Will the course require any visiting faculty?	No
13.	Course objective (about 50 words) To teach the students about the basics of corrosion and factors influencing corrosion. Students will learn about various forms of corrosion and major methods to control it. They will also know about measuring corrosion rate and corrosion monitoring techniques. During presentation assignments, various case studies will also be discussed.	
14.	Course contents (about 100 words) (include laboratory and design activities) Importance of corrosion control in industrial practices, Thermodynamics of corrosion, Broad forms of corrosion – uniform, uneven, pitting, cracking, etc. influencing factors on corrosion. Surface film, Polarisation and effect, Theory of passivity, kinetics of corrosion, Various types of corrosion along with case studies – Galvanic, Thermogalvanic, High temperature corrosion, Intergranular, Pitting, Selective attack (leaching), fretting corrosion – erosion, cavitation, Stress corrosion cracking, hydrogen embrittlement, etc., Various techniques for corrosion evaluation and monitoring, Corrosion Control-Design improvement, Selection of material, fabrication process for corrosion control, Role of residual stress, Changes in operating conditions, Use of inhibitors, Anodic and Cathodic protection, Corrosion resistant coatings, Case studies	

15. Lectures Outline (with topics and number of lectures)

Module No.	Topic	No. of Hours
1	Importance of corrosion control in industrial practices, Genesis of corrosion, factors influencing; Thermodynamics of corrosion; EMF & Galvanic series	10
2	Corrosion rate, units, influencing factors	3
3	Polarization passive film, factors influencing	2
3	Broad forms of corrosion – uniform, uneven, pitting, cracking, etc. Various types of corrosion along with case studies – Galvanic, Thermogalvanic, High temperature corrosion, Intergranular, Pitting, Selective attack (leaching), fretting corrosion – erosion, cavitation, Stress corrosion cracking, hydrogen embrittlement, etc.	13
4	<u>Corrosion Control</u> -Design improvement, Selection of material, fabrication process for corrosion control, Role of residual stress, Changes in operating conditions, Use of inhibitors, Anodic and Cathodic protection, Corrosion resistant coatings, Case studies.	12
5	Various techniques for corrosion evaluation and monitoring.	2
COURSE TOTAL (14 times 'L')		42

16. Brief description of tutorial activities

Module No.	Tutorial activity	No. of Hours
		NIL

17. Brief description of laboratory activities

Module No.	Experiment description	
		NIL

18. Suggested texts and reference materials:

- Design & Corrosion Control; V R Pludek, Macmillan, 1977
- Corrosion resistance coatings technology; Ichiro Suzuki, Marcel Dekker Inc., New York, 1989.
- Corrosion- for students of Science & Engg.; K R Treathway and J Chamberlin, Longman, 1988.
- Fundamentals of Designing corrosion Control: A corrosion aid for the designer; R J Landrum, Natl. Assoc. of Corrosion Engineers, Houston, TX, USA, 1990.
- Corrosion and Corrosion Control H H Uhlig and R.W. Revie, Wiley-Interscience, New York, 1985.
- Corrosion Handbook (Coxmoor's machine & Systems Condition Monitoring); Neil Rothwell and Martin Tullmin, Coxmoor Pub. Co., 1998.

19. Resources required for the course (itemized & student access requirements, if any)

19.1	Software	No
19.2	Hardware	No
19.3	Teaching aides (videos, etc.)	No
19.4	Laboratory	No
19.5	Equipment	No
19.6	Classroom infrastructure	Yes
19.7	Site visits	No

20. Design contents of the course (Percent of student time with examples, if possible)

Date: 13/02/2015

(Signature of the Head of the Centre)

COURSE TEMPLATE

1.	Department / Centre Proposing the course	ITMMEC
2.	Course Title (< 45 characters)	LUBRICANTS
3.	L-T-P structure	2-0-2
4.	Credits	4
5.	Course number	ITL730
6.	Status (category for program)	Elective course

7.	Pre-requisites (course no. / title)	Nil
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8.	Status-vis-à-vis other courses (give course number / title)	
8.1	Overlap with any UG / PG course of the Dept. / Centre)	No
8.2	Overlap with any UG / PG course of the other Dept. / Centre)	No
8.3	Supercedes any existing course	

9.	Not allowed for -(indicate program names)	NA
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10.	Frequency of offering	☐ Every Sem. ☒ 1 st Sem. ☐ 2 nd Sem. ☐ → Either Sem.
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11.	Faculty who will teach the course Prof. Jayashree Bijwe Guest Faculty -	
12.	Will the course require any visiting faculty?	No
13.	Course objective (about 50 words) To teach the students about the basics of lubricants, primary roles, their various types (such as solid, semisolid, liquid and gases); performance properties and evaluation methods; classification systems (such as API, SAE, AGMA, NLGI, ISO). They will also know about oil degradation; role of various additives ; selection criteria for lubricants in various situations; various regimes of lubrication and Stribeck curve;	
14.	Course contents (about 100 words) (include laboratory and design activities) Overview of friction (F), wear (W) and lubrication, Primary role of lubricants in mitigation of F & W & heat transfer medium, Composition and properties of lubricant; Types of lubricants such as mineral oil based, synthetic lubricants , solid lubricants , and greases; Characteristics properties of lubes & greases; their evaluation methods, Classification systems such as API, SAE, AGMA, NLGI, ISO; Additives such as Viscosity-index improver (VII); Anti-oxidant (AO); Anti-friction (AF) Antiwear (AW) Extreme-pressure (EP); Corrosion inhibitors (CI), detergents, dispersants; Selection criteria for lubricants for various tribological situations	

	and applications; Used lubes-environment & health hazards and disposibility and recycling, evaluation of oil degradation by various techniques
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15. Lectures Outline (with topics and number of lectures)

Module No.	Topic	No. of Hours
1	Overview of friction (F), wear (W) and lubrication	1
2	Primary role of lubricants in mitigation of F & W & heat transfer medium	1
3	Composition and properties of lubricant,	1
4	Types of lubricants such as mineral oil based, synthetic lubricants, solid lubricants, greases	12
5	Characteristics properties of lubes & greases; their evaluation methods	2
6	Classification systems such as API, SAE, AGMA, NLGI, ISO	6
7	Additives such as Viscosity-index improver (VII); Anti-oxidant (AO); Anti-friction (AF) Antiwear (AW) Extreme-pressure (EP); Corrosion inhibitors (CI), detergents, dispersants	2
8	Selection criteria for lubricants for various tribological situations and applications	2
9	Used lubes-environment & health hazards & disposibility and recycling, evaluation of oil degradation by various techniques	1
COURSE TOTAL (14 times 'L')		28

16. Brief description of tutorial activities

Module No.	Tutorial activity	No. of Hours
		NIL

17. Brief description of laboratory activities

Module No.	Experiment description	No. of Hours
1	Introduction to experiments, some basic theoretical aspects etc	2
2	Effect of lubrication with dry, oil, grease & water	2
3	Calculate kinematic viscosity and Viscosity Index;	2
4	Determine absolute viscosity of greases & oils	2
5	Flash Point; density, grease penetration, viscosity (Saybolt)	4
6	Wear preventive characteristics and EP characteristics of oils	4
7	Engine Tribology, Degradation in lubricity in used oils	4
8	Oil insoluble, RBOT	2
9	Worn surface studies by SEM	2
10	Repeat turn & lab exam	4
	Total	28

18. Suggested texts and reference materials:

- Lubrication-R C Gunther, Chilton Book Co., New York, 1971.
- Lubrication & Lubricants selection-A R Lansdown, ASME Press, 2004.

19. Resources required for the course (itemized & student access requirements, if any)

19.1	Software	
19.2	Hardware	Yes
19.3	Teaching aides (videos, etc.)	
19.4	Laboratory	Friction & wear labs, Lubricants Labs ITMMEC
19.5	Equipment	Tribometer, various available facilities in labs
19.6	Classroom infrastructure	Yes
19.7	Site visits	No

20. Design contents of the course (Percent of student time with examples, if possible)

Date: 13/02/2015

(Signature of the Head of the Centre)

COURSE TEMPLATE

1.	Department / Centre Proposing the course	ITMMEC
2.	Course Title (< 45 characters)	RISK ANALYSIS AND CONTROL
3.	L-T-P structure	2-1-0
4.	Credits	3
5.	Course number	ITL740
6.	Status (category for program)	Programme Elective

7.	Pre-requisites (course no. / title)	Nil
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8.	Status-vis-à-vis other courses (give course number / title)	
8.1	Overlap with any UG / PG course of the Dept. / Centre)	NA
8.2	Overlap with any UG / PG course of the other Dept. / Centre)	CHL275
8.3	Supercedes any existing course	NA

9.	Not allowed for (indicate program names)	NA
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10.	Frequency of offering	☐ Every Sem. ☐ 1 st Sem. ☐ 2 nd Sem. ☒ Either Sem.
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11.	Faculty who will teach the course Prof. O.P. Gandhi Guest Faculty -	
12.	Will the course require any visiting faculty?	No
13.	Course objective (about 50 words) Appreciation of risk analysis and safety in plants, and application of its concepts and procedures for industrial plants, in general, and hazardous industries in particular.	
14.	Course contents (about 100 words) (include laboratory and design activities) Introduction, Typical hazards, Accident indices, Fire and explosion hazards, Dow's fire and explosion index, Hazards identification procedures for plants and machinery; Preliminary hazard analysis (PHA), Fault Hazard Analysis (FHA), Hazard and operability (HAZOP), What if, Check lists, Failure mode and effects analysis (FMEA), Failure mode, effects and criticality analysis (FMECA), HAZAN: Hazard analysis; FTA (Fault tree analysis), ETA (Event tree analysis), and CCA (Cause consequence analysis), Transportation of hazardous materials, Safety audit, Health and safety aspects of lubricants, Human factors in safety, Risk evaluation and acceptance criteria, Disaster management, Safety codes and Case studies.	

15. Lectures Outline (with topics and number of lectures)

Module No.	Topic	No. of Hours
1	Introduction to the course, background, general terms in risk analysis and safety, and role of maintenance	2
2	Typical hazards and experiences from worldwide accidents, and insurance companies, and Accident indices.	2
3	Fire and explosion hazards, Dow's fire and explosion index	3
4.	Hazards identification procedures for plants and machinery: Preliminary hazard analysis (PHA), Fault Hazard Analysis (FHA), Hazard and operability (HAZOP), What if, Check lists, Failure mode and effects analysis (FMEA), Failure mode, effects and criticality analysis (FMECA), etc.	5
5	Hazard analysis; FTA (Fault tree analysis), ETA (Event tree analysis), and CCA (Cause consequence analysis), etc.	4
6	Transportation of hazardous materials and Safety codes	2
7	Toxicity, Toxicity tests, and health and safety aspects of lubricants	2
8	Mathematical modeling of plant hazards, failures and risk, and Risk evaluation and acceptance criteria	2
9	Human factors in safety and maintenance practices	2
10	Disaster management, and safety audit	2
11	Case studies	2
COURSE TOTAL (14 times 'L')		28

16. Brief description of tutorial activities

Module No.	Tutorial activity	No. of Hours
1	Identifying hazards and estimating accident indices	2
2	Fire and explosion hazards and their estimation using Dow's fire and explosion index guide	2
3	Hazard identification, assessment and recommendation for industrial situations and cases involving well known and well practiced procedures	5
4	Hazard analysis and Risk Assessment – FTA, ETA and CCA	3
5	Safety audit, disaster management, etc.	2
	Total	14

17. Brief description of laboratory activities NOT APPLICABLE

Module No.	Experiment description	

18. Suggested texts and reference materials:

1. Lees, F.P., "Loss prevention in process industries", Vols.1-4, Elsevier Butterworth - Heinemann, Oxford, UK, 2005.
2. "Dow's Fire and Explosion Index - Hazard Classification Guide", 5th Edn., A.I. Ch. E., New York, 1981.
3. "Guidelines for engineering design for process safety", Centre for Chemical Process Safety, A.I.Ch. E., New York, USA, 1993.

19. Resources required for the course (itemized & student access requirements, if any)

19.1	Software	√
19.2	Hardware	
19.3	Teaching aides (videos, etc.)	LCD
19.4	Laboratory	
19.5	Equipment	
19.6	Classroom infrastructure	
19.7	Site visits	√

20. Design contents of the course (Percent of student time with examples, if possible)

20.1	Design-type problems	10%
20.2	Open-ended problems	10%
20.3	Project-type activity	20%
20.4	Open-ended laboratory work	
20.5	Others (please specify)	

Date: 13/02/2015

(Signature of the Head of the Centre)

COURSE TEMPLATE

1.	Department / Centre Proposing the course	ITMMEC
2.	Course Title (< 45 characters)	BULK MATERIALS HANDLING
3.	L-T-P structure	2-0-2
4.	Credits	3
5.	Course number	ITL752
6.	Status (category for program)	Program elective

7.	Pre-requisites (course no. / title)	Nil
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8.	Status-vis-à-vis other courses (give course number / title)	
8.1	Overlap with any UG / PG course of the Dept. / Centre)	No
8.2	Overlap with any UG / PG course of the other Dept. / Centre)	No
8.3	Supercedes any existing course	

9.	Not allowed for (indicate program names)	NA
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10.	Frequency of offering	☐ Every Sem. ☐ 1 st Sem. ☐ 2 nd Sem. ☐ →Either Sem.
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11.	Faculty who will teach the course V K Agarwal Guest Faculty -	
12.	Will the course require any visiting faculty?	No
13.	Course objective (about 50 words) To teach the students about the basics of gas – solid flow, properties of bulk materials and what are the technological options to handle such materials. They would learn the basics of various bulk material handling technologies and how to address the operational problems in such systems.	
14.	Course contents (about 100 words) (include laboratory and design activities) Nature of bulk materials, Flow of gas-solids in pipelines, Mechanical Handling equipments like screw conveyors, belt conveyors and bucket elevators, Pneumatic conveying systems-Components, Design and Selection, Troubleshooting and Maintenance of pneumatic conveying systems, Performance evaluation of alternative systems, Bend erosion-influencing factors, materials selection and potential solutions, Case studies, and Design exercises.	

15. Lectures Outline (with topics and number of lectures)

Module No.	Topic	No. of Hours
1	Bulk materials, their properties and measurement, Fluidization	5
2	Pneumatic conveying systems types, components	3
3	Specification of air requirement	3
4	Conveying capability of materials	4
5	Operational problems	2
6	Design case studies	2
7	Mechanical handling equipments	9
COURSE TOTAL (14 times 'L')		28

16. Brief description of tutorial activities

Module No.	Tutorial activity	No. of Hours

17. Brief description of laboratory activities

Module No.	Experiment description	No. of Hours
1	Measurement of properties	6
2	Fluidization	4
3	Air flow rate evaluation	4
4	Conveying capability	8
5	Erosion studies	2
6	Power plant visit	4
	Total	28

18. Suggested texts and reference materials:

1. C R Woodcock and J S Mason "Bulk Solids Handling" published by Leonard Hill 1993
2. D Mills and V K Agarwal "Pneumatic Conveying Systems" published by Vogel, Germany 2007
3. Marcus, Leung, G. E Klinzing and F. Rizk "Pneumatic Conveying of Solids" published by Chapman and Hall 2010
4. D. Mills, M G Jones and V K Agarwal "Handbook of Pneumatic Conveying Engineering" published by CRC Press. 2004

19. Resources required for the course (itemized & student access requirements, if any)

19.1	Software	
19.2	Hardware	Yes
19.3	Teaching aides (videos, etc.)	
19.4	Laboratory	Project Lab, ITMMEC
19.5	Equipment	
19.6	Classroom infrastructure	Yes
19.7	Site visits	Yes

20. Design contents of the course (Percent of student time with examples, if possible)

Date:13/02/2015

(Signature of the Head of the Centre)

COURSE TEMPLATE

1.	Department / Centre Proposing the course	ITMMEC
2.	Course Title (< 45 characters)	NOISE MONITORING AND CONTROL
3.	L-T-P structure	2-0-2
4.	Credits	3
5.	Course number	ITL760
6.	Status (category for program)	Elective

7.	Pre-requisites (course no. / title)	Nil
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8.	Status-vis-à-vis other courses (give course number / title)	
8.1	Overlap with any UG / PG course of the Dept. / Centre)	No
8.2	Overlap with any UG / PG course of the other Dept. / Centre)	No
8.3	Supercedes any existing course	No

9.	Not allowed for (indicate program names)	NA
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10.	Frequency of offering	☐ Every Sem. ☐ 1 st Sem. ☐ 2 nd Sem. ☒ Either Sem.
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11.	Faculty who will teach the course Prof. Naresh Tandon Guest Faculty -	
12.	Will the course require any visiting faculty?	No
13.	Course objective (about 50 words) To impart knowledge about noise monitoring and its control with emphasis on applications, examples and case studies.	
14.	Course contents (about 100 words) (include laboratory and design activities) Introduction to noise, Properties of noise, Loudness and weighting networks, Noise measurement parameters and standards, Impulse noise, Frequency analysis - octave, one third octave and FFT analysis, Instrumentation for noise measurement and analysis, Sound power, Sound intensity measurement technique with applications, Noise source location, Noise diagnostics, Noise monitoring of machines with examples, Estimation of machinery noise, Cepstrum analysis, Noise control methods, Maintenance and noise reduction, Road vehicle and aircraft noise sources and control, Case studies.	

15. Lectures Outline (with topics and number of lectures)

Module No.	Topic	No. of Hours
1.	Introduction and properties of noise	3
2.	Impulse measurement parameters, standards, impulse noise	4
3.	Frequency analysis of noise	3
4.	Sound intensity and power measurements	4
5.	Noise monitoring and diagnostics	3
6.	Noise control methods with case studies	4
7.	Maintenance and noise reduction	2
8.	Road vehicle and aircraft noise	5
COURSE TOTAL (14 times 'L')		28

16. Brief description of tutorial activities

Module No.	Tutorial activity	No. of Hours

17. Brief description of laboratory activities

Module No.	Experiment description	No. of Hours
1.	Continuous and impulse noise measurements	6
2.	Addition of noise levels and verification of inverse square law	6
3.	Octave, FFT analysis and gear noise	6
4.	Sound power measurement and source location	6
5.	Vehicle/Traffic noise	4
	Total	28

18. Suggested texts and reference materials:

1. Foreman, J.E.K., Sound analysis and noise control, Van Nostrand Reinhold, New York, 1990.
2. Lyon, R.H., Machinery noise and diagnostics, Butterworths, 1987.
3. Beranek, L.L., Noise & vibration control, McGraw Hill, 1971.
4. Bies, D.A. and Hansen, C. H., Engineering noise control, Spon Press, London, 1996.

19. Resources required for the course (itemized & student access requirements, if any)

19.1	Software	Sound intensity software
19.2	Hardware	Yes
19.3	Teaching aides (videos, etc.)	
19.4	Laboratory	Yes
19.5	Equipment	Yes
19.6	Classroom infrastructure	Yes
19.7	Site visits	

20. Design contents of the course (Percent of student time with examples, if possible)

Date: 13/02/2015

(Signature of the Head of the Centre)

COURSE TEMPLATE

1.	Department / Centre Proposing the course	ITMMEC
2.	Course Title (< 45 characters)	BEARING LUBRICATION
3.	L-T-P structure	3-0-0
4.	Credits	3
5.	Course number	ITL 810
6.	Status (category for program)	Program Elective

7.	Pre-requisites (course no. / title)	
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8.	Status-vis-à-vis other courses (give course number / title)	
8.1	Overlap with any UG / PG course of the Dept. / Centre)	No
8.2	Overlap with any UG / PG course of the other Dept. / Centre)	MEL748
8.3	Supercedes any existing course	

9.	Not allowed for (indicate program names)	
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10.	Frequency of offering	☐ Every Sem. ☐ 1 st Sem. ☐ 2 nd Sem. ☐ √Either Sem.
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11.	Faculty who will teach the course: Dr. Deepak Kumar Guest Faculty -	
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12.	Will the course require any visiting faculty?	No
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13.	Course objective (about 50 words) The course will introduce the fundamentals of lubrication with main stress towards the bearing lubrication. Numerical methods will be introduced and used for various constitutive equations solving.	
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14.	Course contents (about 100 words) (include laboratory and design activities) Introduction-Historical background, Bearing concepts and typical applications. Viscous flow concepts-Conservation of laws and its derivations: continuity, momentum (N-S equations) and energy, Solutions of Navier-Stokes equations. Order of magnitude analysis, General Reynolds equation-2D and 3D (Cartesian and Cylindrical), Various mechanisms of pressure development in an oil film, Performance parameters. Boundary Layer Concepts-Laminar and turbulent flow in bearings, mathematical modeling of flow in high-speed bearings. Elastic Deformation of bearing surfaces-Contact of smooth and rough solid surfaces, elasticity equation, Stress distribution and local deformation in mating surfaces due to loadings, methods to avoid singularity effects, Estimation of elastic deformation by numerical methods-Finite Difference Method (FDM), Governing equation for evaluation of film thickness in Elastohydrodynamic Lubrication (EHL) and its solution, Boundary conditions.	
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	Development of computer programs for mathematical modeling of flow in bearings, Numerical simulation of elastic deformation in bearing surfaces by FDM.
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15. Lectures Outline (with topics and number of lectures)

Module No.	Topic	No. of Hours
1.	Historical background, Bearing concepts and typical applications	3
2.	Viscous flow concepts-Conservation of laws and its derivations: continuity, momentum (N-S equations) and energy, Solutions of Navier-Stokes equations. Order of magnitude analysis,	6
3.	General Reynolds equation-2D and 3D (Cartesian and Cylindrical), Various mechanisms of pressure development in an oil film, Performance parameters.	6
4.	Boundary Layer Concepts-Laminar and turbulent flow in bearings, mathematical modeling of flow in high-speed bearings.	8
5.	Elastic Deformation of bearing surfaces-Contact of smooth and rough solid surfaces, elasticity equation, Stress distribution and local deformation in mating surfaces due to loadings, methods to avoid singularity effects,	8
6.	Estimation of elastic deformation by numerical methods-Finite Difference Method (FDM), Governing equation for evaluation of film thickness in Elasto Hydrodynamic Lubrication (EHL) and its solution, Boundary conditions.	6
7.	Development of computer programs for mathematical modeling of flow in bearings, Numerical simulation of elastic deformation in bearing surfaces by FDM.	5
COURSE TOTAL (14 times 'L')		42

16. Brief description of tutorial activities : NA

Module No.	Tutorial activity	No. of Hours

17. Brief description of laboratory activities : NA

Module No.	Experiment description	No. of Hours
1.		

18. Suggested texts and reference materials:

1. D.M. Pirro and A.A. Wessol, 'Lubrication Fundamentals' CRC Press, 2001
2. Avraham HArnor, 'Bearing Design in Machinery: Engineering Tribology and Lubrication', Marcel Dekker, Inc., 2005
3. Ping Hunag, ' Numerical Calculations of Lubrication: Methods and Programs', Wiley & Sons, Inc. 2013.

19. Resources required for the course (itemized & student access requirements, if any)

19.1	Software	MATLAB
19.2	Hardware	None
19.3	Teaching aides (videos, etc.)	
19.4	Laboratory	
19.5	Equipment	
19.6	Classroom infrastructure	Projector
19.7	Site visits	None

20. Design contents of the course (Percent of student time with examples, if possible)

20.1	Design –type problems	20%
20.2	Open- ended problems	10%
20.3	Project- type activities	15%
20.4	Open ended laboratory work	
20.5	Others (Please specify)	

Date: 13/02/2015

(Signature of the Head of the Centre)