

Program: MTech in Transportation Engineering

Category	PC			PE	RE	Total
	Courses	Thesis	Subtotal			
Proposed	15	21	36	12	6	54
Institute Criteria		Min 18; Max 24	Min 24	Min 12		Min 48; Max 54

Semester	Courses				Contact h/week				Credits
					L	T	P	Total	
I	PC Urban & Regional Transport Planning (3-0-2) [4]	PC Pavement Materials and Design of Pavements (3-0-2) [4]	PC Traffic Engineering (3-0-2) [4]	RE 1* (3-0-0 or 2-0-2) [3]	Min 11; Max 12	0	Min 6; Max 8	18	15
II	PE 1 (2-0-2) [3]	PE 2 (2-0-2) [3]	PE 3 (2-0-2) [3]	RE 2 [#] (3-0-0 or 2-0-2) [3]	Min 8; Max 9		Min 6; Max 8	12	12
Summer	PC Advanced Topics in Transportation Engineering (0-0-6) [3]				0	0	6	6	3
III	PE 4 (2-0-2) [3]	PC Major Project Part 1 (0-0-18) [9]			3	0	18	24	12
IV	PC Major Project Part 2 (0-0-24) [12]				0	0	24	24	12

* Should be listed in restricted elective course category.

Any course (relevant to research area) offered in that semester **with consent** of thesis supervisor. Alternatively minor project can be opted.

MTech in Transportation Engineering

Program Core [PC]

Course Number	Course Title	L-T-P	Credits
CVL740	Pavement Materials and Design of Pavements	3-0-2	4
CVL741	Urban and Regional Transportation Planning	3-0-2	4
CVL742	Traffic Engineering	3-0-2	4
CVS852	Advanced Topics in Transportation Engineering	0-0-6	3
CVD853	Major Project Part 1	0-0-24	12
CVD854	Major Project Part 2	0-0-24	12

Program Elective [PE]

Course Number	Course Title	L-T-P	Credits
CVL743	Airport Planning and Design	3-0-0	3
CVL744	Transportation Infrastructure Design	2-0-2	3
CVL745	Modeling of Pavement Materials	2-0-2	3
CVL746	Public Transportation Systems	3-0-0	3
CVL747	Transportation Safety and Environment	3-0-0	3
CVL750	Intelligent Transportation Systems	3-0-0	3
CVS753	Minor Project in Transportation Engineering [@]	0-0-6	3
CVS754	Independent Study	0-0-6	3
CVL840	Planning and Design of Sustainable Transport Systems	3-0-0	3
CVL841	Advanced Transportation Modelling	2-0-2	3
CVL842	Geometric Design of Roads	2-0-2	3
CVL844	Transportation Infrastructure Management	3-0-0	3
CVL845	Viscoelastic Behavior of Bituminous Materials	3-0-0	3
CVL846	Transportation System Management	3-0-0	3
CVL847	Transportation Economics	3-0-0	3
CVL849	Traffic Flow Modelling	3-0-0	3
CVL850	Transportation Logistics	3-0-0	3
CVL851	Special Topics in Transportation Engineering	3-0-0	3

[@] Student can register for this course only once during entire MTech Program.

Restricted Elective [RE]

Course Number	Course Title	L-T-P	Credits
CVL763	Analytical and Numerical Methods for Structural Engineering	3-0-0	3
CVL729	Environmental Statistics and Experimental Design	2-0-2	3
MEL TBD	Probability and Statistics	3-0-0	3
CVL731	Optimization Techniques in Water Resources	3-0-0	3
CVS753	Minor Project in Transportation Engineering	0-0-6	3
	Any course relevant to research area offered in that semester with consent of thesis supervisor.	3-0-0	3

COURSE TEMPLATE

1.	Department /Centre proposing the course	Civil Engineering
2.	Course Title (<i>< 45 characters</i>)	ADVANCED TOPICS IN TRANSPORTATION ENGINEERING
3.	L-T-P structure	0 - 0 - 6
4.	Credits	3
5.	Course number	CVS852
6.	Status (<i>category for program</i>)	Program core for MTech in Transportation Engineering

7.	Pre-requisites (course no./title)	CVL740, CVL741, CVL742
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8.	Status vis-à-vis other courses (<i>give course number/title</i>)	
8.1	Overlap with any UG/PG course of the Dept./Centre	Nil
8.2	Overlap with any UG/PG course of other Dept./Centre	Nil
8.3	Supercedes any existing course	

9.	Not allowed for (indicate program names)	Any other MTech program
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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. Geetam Tiwari Dr. S. K. Deb Dr. Kalaga Ramachandra Rao Dr. Aravind Krishna Swamy	
12.	Will the course require any visiting faculty?	No

13.	Course objective (<i>about 50 words</i>): (i) To provide exposure to research topics in the area of transportation engineering relavent to their MTech thesis.	
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14.	Course contents (<i>about 100 words</i>) (<i>Include laboratory/design activities</i>): This is an advanced course for MTech Transportation engineering program where students will study a specialized topic within transportation engineering (including but not limited to transportation planning, traffic engineering and pavement engineering). The topic shall be announced by instructor at the beginning. The performance of student in this course will be evaluated through presentation(s) and report(s) made by student during the registered term.	
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15. Lecture Outline *(with topics and number of lectures)*

Module no.	Topic	No. of hours
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		
11		
12		
COURSE TOTAL (14 times 'L')		

16. Brief description of tutorial activities

NIL

17. Brief description of laboratory activities

Module no.	Experiment description	No. of hours
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		
COURSE TOTAL (14 times 'P')		84

18. Suggested texts and reference materials

STYLE: Sonntag, R. E., Borgnakke, C., and Van Wylen, G. J., *Fundamentals of Thermodynamics*, 5th Ed., John Wiley, 2000.

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

19.1	Software	
19.2	Hardware	
19.3	Teaching aides (videos, etc.)	
19.4	Laboratory	
19.5	Equipment	

19.6	Classroom infrastructure	
19.7	Site visits	

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

20.1	Design-type problems	
20.2	Open-ended problems	100
20.3	Project-type activity	
20.4	Open-ended laboratory work	
20.5	Others (please specify)	

Date:

(Signature of the Head of the Department)

COURSE TEMPLATE

1.	Department /Centre proposing the course	Civil Engineering
2.	Course Title (<i>< 45 characters</i>)	ADVANCED TRANSPORTATION MODELLING
3.	L-T-P structure	2 - 0 - 2
4.	Credits	3
5.	Course number	CVL841
6.	Status (<i>category for program</i>)	Program elective for MTech in Transportation Engineering Open elective for other MTech programs
7.	Pre-requisites (<i>course no./title</i>)	MTech: CVL741; BTech: Instructor's permission
8.	Status vis-à-vis other courses (<i>give course number/title</i>)	
8.1	Overlap with any UG/PG course of the Dept./Centre	10% with CEL741
8.2	Overlap with any UG/PG course of other Dept./Centre	Nil
8.3	Supercedes any existing course	CEL785
9.	Not allowed for (<i>indicate program names</i>)	
10.	Frequency of offering	☐ Every sem ☐ 1 st sem ☐ 2 nd sem ☒ Either sem
11.	Faculty who will teach the course Prof. Geetam Tiwari Dr. Kalaga Ramachandra Rao Dr. S. K. Deb Dr. Aravind Krishna Swamy	
12.	Will the course require any visiting faculty?	No
13.	Course objective (<i>about 50 words</i>): At the end of the course the student should be able to: (i) Use the Four Step Transport System Models, (ii) Develop Trip generation and travel demand models using househld data, (iii) Understand Statistical Techniqueus used for travel demand and network assignment models.	
14.	Course contents (<i>about 100 words</i>) (<i>Include laboratory/design activities</i>): Systems Approach to Travel demand models, Trip generation Models Using Different Statistical techniques, Trip distribution, Discrete Choice Logit, Nested Logit and other Models, Network Assignment, Traffic Assignment Using User Equilibrium and Systems Optimization Techniques, Revealed preference and	

	Stated Preference surveys , Analysis of Ranked and Rated data, Demand models for Nonmotorised transport and Public Transport systems.
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15. Lecture Outline (with topics and number of lectures)

Module no.	Topic	No. of hours
1	Introduction to Statistical Techniques, Hypothesis Testing	2
2	trip generation using OLS Regression, Maximum likelihood methods	2
3	Trip Distribution, Entropy Maximization Approach, Gravity Models	4
4	Discrete choice Models I(Logit, Nested Logit)	6
5	Discrete Choice Models (Probit, Ranked and Rated Data)II	4
6	Traffic Assignment(User Equilibrium, All or Nothing Assignment) I	2
7	Traffic Assignment (System Optimization)II	2
8	Modelling Public Transport demand	2
9	Modelling NMT demand	2
10	Stated Preference Survey	2
11		
12		
COURSE TOTAL (14 times 'L')		28

16. Brief description of tutorial activities

NIL

17. Brief description of laboratory activities

Module no.	Experiment description	No. of hours
1	Trip Generation using SPSS	2
2	Digitization on TRANSCAD	2
3	Trip Distribution on TRANSCAD	6
4	Mode Choice using TRANSCAD	6
5	Modelling Public Transport System on TRANSCAD	6
6	Modelling Bicycle Trips on TRANSCAD	4
7	Comparison with EMME/VISSUM	2
8		
9		
10		
COURSE TOTAL (14 times 'P')		28

18. Suggested texts and reference materials

STYLE: Sonntag, R. E., Borgnakke, C., and Van Wylen, G. J., *Fundamentals of Thermodynamics*, 5th Ed., John Wiley, 2000.

1. Cascetta, E., *Transportation Systems Engineering: Theory and Methods*, Kluwer, 2001
2. Bell, MGH and Iida, H. *Transportation Network Analysis*, John Wiley, 1997
3. Ortuzar, J.D. and Willumsen, L.G. *Modelling Transport*, John Wiley, 2001
4. Washington, Simon P, Karlaftis, Matthew G, and Mannering, Fred, *Statistical and Econometric Methods for Transportation Data Analysis* Chapman and Hall/CR, 2003
5. Hensher David A, Rose, John M, and Greene, William, H, *Applied Choice Analysis, A Primer*, Cambridge University Press, 2005

6. Hensher, David A, Kenneth Button, Handbook of Transport Modelling, Pergamon Press, 2000

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

19.1	Software	SPSS, STATA, TRANSCAD, VISSUM, EMMEIII, ARC GIS, NLOGIT
19.2	Hardware	
19.3	Teaching aides (videos, etc.)	
19.4	Laboratory	Computer Lab
19.5	Equipment	
19.6	Classroom infrastructure	Multimedia projector
19.7	Site visits	

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

20.1	Design-type problems	
20.2	Open-ended problems	10%
20.3	Project-type activity	30%
20.4	Open-ended laboratory work	20%
20.5	Others (please specify)	

Date:

(Signature of the Head of the Department)

COURSE TEMPLATE

1.	Department /Centre proposing the course	Civil Engineering
2.	Course Title (<i>< 45 characters</i>)	AIRPORT PLANNING AND DESIGN
3.	L-T-P structure	3 - 0 - 0
4.	Credits	3
5.	Course number	CVL743
6.	Status (<i>category for program</i>)	Program elective for MTech in Transportation Engineering Open elective for other MTech programs
7.	Pre-requisites (<i>course no./title</i>)	MTech: Nil; BTech: Instructor's permission
8.	Status vis-à-vis other courses (<i>give course number/title</i>)	
8.1	Overlap with any UG/PG course of the Dept./Centre	Nil
8.2	Overlap with any UG/PG course of other Dept./Centre	Nil
8.3	Supercedes any existing course	
9.	Not allowed for (<i>indicate program names</i>)	
10.	Frequency of offering	☐ Every sem ☐ 1 st sem ☐ 2 nd sem ☒ Either sem
11.	Faculty who will teach the course Dr. Aravind Krishna Swamy Dr. Kalaga Ramachandra Rao Prof. Geetam Tiwari Dr. S. K. Deb	
12.	Will the course require any visiting faculty?	No
13.	Course objective (<i>about 50 words</i>): This course is designed to provide the student with tools and methods to analyze and plan airport infrastructure. The topics covered in course can be broadly classified into (i) Aircraft characteristics as related to airport configuration, (ii) Demand modeling, (iii) Design of airport facilities, (iv) Financial aspects of airport construction and operation.	
14.	Course contents (<i>about 100 words</i>) (<i>Include laboratory/design activities</i>): Overview of air transport; Forecasting demand-passenger, freight; Aircraft characteristics; Airport planning-requirements site selection, layout plan;	

	Geometric design of runway, taxiway and aprons; Airport capacity-airside, landside; Passenger terminal-functions, passenger and baggage flow; Airport pavement design and drainage; Parking and apron design; Air cargo facilities; Air traffic control lighting and signing; Airport safety; Environmental impact of airports; Airport financing and economic analysis.
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15. Lecture Outline *(with topics and number of lectures)*

Module no.	Topic	No. of hours
1	Overview of air transport	2
2	Forecasting demand-passenger, freight	4
3	Aircraft characteristics	2
4	Airport planning-requirements site selection, layout plan	4
5	Geometric design of runway, taxiway and aprons	4
6	Airport capacity-airside, landside	4
7	Passenger terminal-functions, passenger and baggage flow	4
8	Airport pavement design and drainage; Parking and apron design	3
9	Air cargo facilities	4
10	Air traffic control lighting and signing	4
11	Airport safety; Environmental impact of airports	3
12	Airport financing and economic analysis	4
COURSE TOTAL (14 times 'L')		42

16. Brief description of tutorial activities

NA

17. Brief description of laboratory activities

Module no.	Experiment description	No. of hours
1	NA	
2	NA	
3	NA	
4	NA	
5	NA	
6	NA	
7	NA	
8	NA	
9	NA	
10	NA	
COURSE TOTAL (14 times 'P')		

18. Suggested texts and reference materials

STYLE: Author name and initials, Title, Edition, Publisher, Year.

1. Ashford, N. J., Mumayiz, S., and Wright, P. H., Airport Engineering: Planning, Design and Development of 21st Century Airports, John Wiley and Sons, 2011.
2. Horonjeff, R., McKelvey, F., Sproule, W. and Young, S., Planning and Design of Airports, McGraw-Hill, 2010.
3. DeNeufville, R. and Odoni, A., Planning Design and Management, McGraw-Hill, 2003.
4. Young, S. and Wells, A., Airport Planning and Management, McGraw-Hill Professional Publishing, 2011.

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

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

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

20.1	Design-type problems	5
20.2	Open-ended problems	5
20.3	Project-type activity	10
20.4	Open-ended laboratory work	
20.5	Others (please specify)	10 (Simulation)

Date:

(Signature of the Head of the Department)

COURSE TEMPLATE

1.	Department /Centre proposing the course	Civil Engineering
2.	Course Title (<i>< 45 characters</i>)	GEOMETIRC DESIGN OF ROADS
3.	L-T-P structure	2 - 0 - 2
4.	Credits	3
5.	Course number	CVL842
6.	Status (<i>category for program</i>)	Program elective for MTech in Transportation Engineering Open elective for other MTech programs
7.	Pre-requisites (<i>course no./title</i>)	MTech: CVL741, CVL742; BTech: CVL261 and one TE elective
8.	Status vis-à-vis other courses (<i>give course number/title</i>)	
8.1	Overlap with any UG/PG course of the Dept./Centre	<10% with CVL261
8.2	Overlap with any UG/PG course of other Dept./Centre	Nil
8.3	Supercedes any existing course	
9.	Not allowed for (<i>indicate program names</i>)	
10.	Frequency of offering	☐ Every sem ☐ 1 st sem ☐ 2 nd sem ☒ Either sem
11.	Faculty who will teach the course Dr. Kalaga Ramachandra Rao Prof. Geetam Tiwari Dr. S. K. Deb Dr. Aravind Krishna Swamy	
12.	Will the course require any visiting faculty?	No
13.	Course objective (<i>about 50 words</i>): This course intends to equip the students with the road geometry design aspects At the end of the course, the student would be able to (i) Understand basic geometric design elements and controls of a typical highway or road section, (ii) Identify the relevant codes of practice and relate it to the design, (iii) Be able to do the basic design elements through the software.	
14.	Course contents (<i>about 100 words</i>) (<i>Include laboratory/design activities</i>): Introduction to basic road geoemtric design elements and methodology - design philosphy and design techniques; Design controls - human, vehicle and speed related factors. Road vehicle performance - road vehicle dynamics -	

	tractive and resisting forces. Braking forces. Theoretical and practical stopping distances. Elements of geometric design - cross section elements; Horizontal Alignment - tangents, curves, transitions, superelevation; Vertical Alignment - grades and curves; Coordination of Horizontal and Vertical Alignment. Design of Intersections at-grade- design principles, channelization, roundabouts, Interchanges- types, warrants, lane balancing; Road side safety- hazards and clear zone concept, traffic safety barriers, impact attenuation
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15. Lecture Outline (*with topics and number of lectures*)

Module no.	Topic	No. of hours
1	Introduction to basic road geometric design elements and methodology - design philosophy and design techniques;	1 2 2
2	Design controls - human, vehicle and speed related factors.	3
3	Road vehicle performance - road vehicle dynamics - tractive and resisting forces. Braking forces. Theoretical and practical stopping distances.	1 1 1 2
4	Elements of geometric design - cross section elements;	1
5	Horizontal Alignment - tangents, curves, transitions, superelevation;	1 1 1 2
6	Vertical Alignment - grades and curves;	3
7	Coordination of Horizontal and Vertical Alignment.	1
8	Design of Intersections at-grade- design principles, channelization, roundabouts,	2 2
9	Interchanges- types, warrants, lane balancing;	2
10	Road side safety- hazards and clear zone concept,	2
11	Traffic safety barriers, impact attenuation	1
12		
COURSE TOTAL (14 times 'L')		28

16. Brief description of tutorial activities

NIL

17. Brief description of laboratory activities

Module no.	Experiment description	No. of hours
1	Introduction to MX-ROADS	2
2	Surface analysis	2
3	Quick alignment	2
4	Quick Horizontal alignment	2
5	Quick Vertical alignment	2
6	Carriageway design	2
7	Road widening	2
8	Shoulder design	2
9	Pavement layer design and dynamic sections	2+2
10	Report and drawing generations	2+2
COURSE TOTAL (14 times 'P')		28

18. Suggested texts and reference materials

STYLE: Sonntag, R. E., Borgnakke, C., and Van Wylen, G. J., *Fundamentals of Thermodynamics*, 5th Ed., John Wiley, 2000.

1. Mannering, F.L. and Washburn S.S. Principles of Highway Engineering and Traffic

Analysis, 5th Edition John Wiley, 2009.

2. Banks, J.H. An Introduction to Transportation Engineering, McGraw Hill, 2000.
3. AASHTO, A Policy on Geometric Design of Highways and Streets , 2011.
4. AustRoads, Guide to Geometric Design, Part 3: Geometric Design, 2010.
5. Rogers, M. Highway Engineering, 2nd Edition, Blackwell Publishing, 2nd Edn, 2008.
6. NRA Geometric Design Guideline, South African National Roads Agency, 2002.
7. Underwood, R.T. Geometric Design of Highways, McMillan, 1996.
8. Kadiyali, L.R. Principles and Practice of Highway Engineering, Khanna Publishers, 2000.

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

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

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

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

Date:

(Signature of the Head of the Department)

INDEPENDENT STUDY TEMPLATE

1.	Department /Centre proposing the course	Civil Engineering
2.	Course Title (<i>< 45 characters</i>)	INDEPENDENT STUDY
3.	L-T-P structure	0 - 3 - 0
4.	Credits	3
5.	Course number	CVS754
6.	Status (<i>category for program</i>)	Program elective for MTech in Transportation Engineering Open elective for other MTech programs
7.	Pre-requisites (<i>course no./title</i>)	Instructor's permission
8.	Supersedes any existing course	NONE
9.	Frequency of offering	☐ Every sem ☐ 1 st sem ☐ 2 nd sem ☒ Either sem
10.	FACULTY WHO WILL SUPERVISE PROJECT STUDY Prof. Geetam Tiwari Dr. S. K. Deb Dr. Kalaga Ramachandra Rao Dr. Aravind Krishna Swamy	
11.	Will the PROJECT SUPERVISION require any visiting faculty?	May be invited on request by faculty supervisor/student
12.	PROJECT objective (<i>about 50 words</i>): To study an identified research area and prepare a report on the state of the art.	

13. Brief description of laboratory activities

Module no.	Experiment description	No. of hours
1	Specific to the problem taken up for the study	Open

14. Suggested texts and reference materials

STYLE: Author name and initials, Title, Edition, Publisher, Year.

Relevant, Contextual research articles, reports and books

15. Resources required for the STUDY (*itemized & student access requirements, if any*)

19.1	Software	Yes
19.2	Hardware	Yes
19.3	PRESENTATION aides (videos, etc.)	Yes
19.4	Laboratory	Yes
19.5	Equipment	Yes
19.6	Classroom infrastructure	No
19.7	Site visits	May be required as part of the study.

Date:

(Signature of the Head of the Department)

COURSE TEMPLATE

1.	Department /Centre proposing the course	Civil Engineering
2.	Course Title (<i>< 45 characters</i>)	INTELLIGENT TRANSPORTATION SYSTEMS
3.	L-T-P structure	3 - 0 - 0
4.	Credits	3
5.	Course number	CVL750
6.	Status (<i>category for program</i>)	Program elective for MTech in Transportation Engineering Open elective for other MTech programs
7.	Pre-requisites (<i>course no./title</i>)	MTech: Nil; BTech: Instructor's permission
8.	Status vis-à-vis other courses (<i>give course number/title</i>)	
8.1	Overlap with any UG/PG course of the Dept./Centre	Nil
8.2	Overlap with any UG/PG course of other Dept./Centre	Nil
8.3	Supercedes any existing course	
9.	Not allowed for (<i>indicate program names</i>)	
10.	Frequency of offering	☐ Every sem ☐ 1 st sem ☐ 2 nd sem ☒ Either sem
11.	Faculty who will teach the course Dr. Kalaga Ramachandra Rao Prof. Geetam Tiwari Dr. Aravind Krishna Swamy Dr. S. K. Deb	
12.	Will the course require any visiting faculty?	No
13.	Course objective (<i>about 50 words</i>): This course is designed to provide over view of emerging aspects of the intelligent transportation systems. The following are the expected outcomes of the course (i) To grasp the basic concepts of the ITS, (ii) To understand the structure and modules of a typical ITS setup, (iii) To get an overview of the applications - mobile, voice, internet , (iv) To understand the relevant hardware and software, (v) To have an idea of the necessary orgnaizational structure for implementation.	
14.	Course contents (<i>about 100 words</i>) (<i>Include laboratory/design activities</i>):	

	Introduction to Intelligent Transportation Systems (ITS); ITS Organizational Issues, the fundamental concepts of Intelligent Transportation Systems (ITS) to students with interest in engineering, transportation systems, communication systems, vehicle technologies, transportation planning, transportation policy, and urban planning. ITS in transportation infrastructure and vehicles, that improve transportation safety, productivity, environment, and travel reliability. Mobile device applications of ITS such as trip planners, ETA s of public transit vehicles
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15. Lecture Outline (*with topics and number of lectures*)

Module no.	Topic	No. of hours
1	Introduction to Intelligent Transportation Systems (ITS)	1
2	Advanced Traveler Information Systems (ATIS)	3
3	ITS Highway Safety Perspective	3
4	Environmental Aspects of ITS; Connected Vehicle Technology and Applications	5
5	ITS Standards and Architecture; Organizational structure	3
6	ITS Telecommunications	3
7	Travel Information Systems Expected Time of Arrivals and applications in Public transit information	6 3
8	Interactive Voice Recognition (IVR)	1
9	Mobile Applications	2
10	Economics of ITS – Revenue Generation Models	3
11	ITS and Security; ITS Policy Issues	3
12	International ITS Programs Case Studies: applications in bus transport, metro and highways	6
COURSE TOTAL (14 times 'L')		42

16. Brief description of tutorial activities

NIL

17. Brief description of laboratory activities

Module no.	Experiment description	No. of hours
1	NA	
2	NA	
3	NA	
4	NA	
5	NA	
6	NA	
7	NA	
8	NA	
9	NA	
10	NA	
COURSE TOTAL (14 times 'P')		

18. Suggested texts and reference materials

STYLE: Sonntag, R. E., Borgnakke, C., and Van Wylen, G. J., *Fundamentals of Thermodynamics*, 5th Ed., John Wiley, 2000.

1. Sussman, J.M. Perspectives on Intelligent Transportation Systems, Springer, Berlin, 2010.
2. Ghosh, S., Lee, T.S. Intelligent Transportation Systems: New Principles and Architectures, CRC Press, 2000.
3. Mashrur A. Chowdhury, and Adel Sadek, Fundamentals of Intelligent Transportation Systems Planning, Artech House, Inc., 2003.

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

19.1	Software	MS Excel, Matlab
19.2	Hardware	NIL
19.3	Teaching aides (videos, etc.)	OHP, Laptop, Multimedia projector
19.4	Laboratory	NIL
19.5	Equipment	NIL
19.6	Classroom infrastructure	~75 students
19.7	Site visits	

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

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

Date:

(Signature of the Head of the Department)

MAJOR PROJECT TEMPLATE

1.	Department /Centre proposing the course	Civil Engineering
2.	Course Title (<i>< 45 characters</i>)	MAJOR PROJECT I
3.	L-T-P structure	0 - 0 - 18
4.	Credits	9
5.	Course number	CVD853
6.	Status (<i>category for program</i>)	Program core for MTech in Transportation Engineering
7.	Pre-requisites (course no./title)	CVL740, CVL741, CVL742
8.	Supersedes any existing course	
9.	Frequency of offering	☐ Every sem ☐ 1 st sem ☐ 2 nd sem ☒ Either sem
10.	FACULTY WHO WILL SUPERVISE PROJECT STUDY Prof. Geetam Tiwari Dr. S. K. Deb Dr. Kalaga Ramachandra Rao Dr. Aravind Krishna Swamy	
11.	Will the PROJECT SUPERVISION require any visiting faculty?	May be invited on request by faculty supervisor/student
12.	PROJECT objective (<i>about 50 words</i>): (i) To initiate students into research on well defined or open ended problems, (ii) To foster/promote understanding of identified problem domains based on laboratory and/or numerical modeling based approaches, (iii) To develop theoretical formulations of specific contextual physical processes, (iv) To develop improved design methodologies in the area of transportation engineering.	

13. Brief description of laboratory activities

Module no.	Experiment description	No. of hours
1	Specific to the problem taken up for the study	Open

14. Suggested texts and reference materials

STYLE: Author name and initials, Title, Edition, Publisher, Year.

Relevant, Contextual research articles, reports and books

15. Resources required for the STUDY (*itemized & student access requirements, if any*)

19.1	Software	Yes
19.2	Hardware	Yes
19.3	PRESENTATION aides (videos, etc.)	Yes
19.4	Laboratory	Yes
19.5	Equipment	Yes
19.6	Classroom infrastructure	No
19.7	Site visits	May be required as part of the study.

Date:

(Signature of the Head of the Department)

MAJOR PROJECT TEMPLATE

1.	Department /Centre proposing the course	Civil Engineering
2.	Course Title (<i>< 45 characters</i>)	MAJOR PROJECT II
3.	L-T-P structure	0 - 0 - 24
4.	Credits	12
5.	Course number	CVD854
6.	Status (<i>category for program</i>)	Program core for MTech in Transportation Engineering

7.	Pre-requisites (course no./title)	CVD853
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8.	Supersedes any existing course	
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9.	Frequency of offering	☐ Every sem ☐ 1 st sem ☐ 2 nd sem ☒ Either sem
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10.	FACULTY WHO WILL SUPERVISE PROJECT STUDY Prof. Geetam Tiwari Dr. S. K. Deb Dr. Kalaga Ramachandra Rao Dr. Aravind Krishna Swamy	
11.	Will the PROJECT SUPERVISION require any visiting faculty?	May be invited on request by faculty supervisor/student
12.	PROJECT objective (<i>about 50 words</i>): (i) To initiate students into research on well defined or open ended problems, (ii) To foster/promote understanding of identified problem domains based on laboratory and/or numerical modeling based approaches, (iii) To develop theoretical formulations of specific contextual physical processes, (iv) To develop improved design methodologies in the area of transportation engineering.	

13. Brief description of laboratory activities

Module no.	Experiment description	No. of hours
1	Specific to the problem taken up for the study	Open

14. Suggested texts and reference materials

STYLE: Author name and initials, Title, Edition, Publisher, Year.

Relevant, Contextual research articles, reports and books

15. Resources required for the STUDY (*itemized & student access requirements, if any*)

19.1	Software	Yes
19.2	Hardware	Yes
19.3	PRESENTATION aides (videos, etc.)	Yes
19.4	Laboratory	Yes
19.5	Equipment	Yes
19.6	Classroom infrastructure	No
19.7	Site visits	May be required as part of the study.

Date:

(Signature of the Head of the Department)

MINOR PROJECT TEMPLATE

1.	Department /Centre proposing the course	Civil Engineering
2.	Course Title (<i>< 45 characters</i>)	MINOR PROJECT IN TRANSPORTATION ENGINEERING
3.	L-T-P structure	0 - 0 - 6
4.	Credits	3
5.	Course number	CVS753
6.	Status (<i>category for program</i>)	Program Elective for MTech in Transportation Engineering

7.	Pre-requisites (course no./title)	MTech: Nil
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8.	Supersedes any existing course	NONE
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9.	Frequency of offering	☐ Every sem ☐ 1 st sem ☐ 2 nd sem ☒ Either sem
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10.	FACULTY WHO WILL SUPERVISE PROJECT STUDY Prof. Geetam Tiwari Dr. S. K. Deb Dr. Kalaga Ramachandra Rao Dr. Aravind Krishna Swamy	
11.	Will the PROJECT SUPERVISION require any visiting faculty?	May be invited on request by faculty supervisor/student
12.	PROJECT objective (<i>about 50 words</i>): (i) To explore a prescribed problem based on laboratory and/or numerical modeling based approaches, (ii) To explore design methodologies on the area of transportation engineering.	

13. Brief description of laboratory activities

Module no.	Experiment description	No. of hours
1	Specific to problem taken up for the study	Open

14. Suggested texts and reference materials

STYLE: Author name and initials, Title, Edition, Publisher, Year.

Relevant, Contextual research articles, reports and books

15. Resources required for the STUDY (*itemized & student access requirements, if any*)

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

May be required as part of the study.

Date:

(Signature of the Head of the Department)

COURSE TEMPLATE

1.	Department /Centre proposing the course	Civil Engineering
2.	Course Title (<i>< 45 characters</i>)	MODELING OF PAVEMENT MATERIALS
3.	L-T-P structure	2 - 0 - 2
4.	Credits	3
5.	Course number	CVL745
6.	Status (<i>category for program</i>)	Program elective for MTech in Transportation Engineering Open elective for other MTech programs
7.	Pre-requisites (<i>course no./title</i>)	MTech: Nil; BTech: Instructor's permission
8.	Status vis-à-vis other courses (<i>give course number/title</i>)	
8.1	Overlap with any UG/PG course of the Dept./Centre	Nil
8.2	Overlap with any UG/PG course of other Dept./Centre	Nil
8.3	Supercedes any existing course	Nil
9.	Not allowed for (<i>indicate program names</i>)	
10.	Frequency of offering	☐ Every sem ☐ 1 st sem ☐ 2 nd sem ☒ Either sem
11.	Faculty who will teach the course Dr. Aravind Krishna Swamy Dr. Kalaga Ramachandra Rao Prof. Geetam Tiwari Dr. S. K. Deb	
12.	Will the course require any visiting faculty?	No
13.	Course objective (<i>about 50 words</i>): To provide understanding of fundamentals of materials (soil, aggregate systems, asphalt, asphalt concrete) including (i) Theoretical, (ii) Numerical, (iii) Exeperimental.	
14.	Course contents (<i>about 100 words</i>) (<i>Include laboratory/design activities</i>): Role of constitutive modeling; Laboratory testing in relation to constitutive modeling: elastic modulus, resilient modulus, complex modulus, creep, rheological tests; Introduction to continuum mechanics: strain tensor, stress tensor, isotropy, anisotropy, constitutive relationships; Factors affecting	

	material behavior: temperature, rate, time, confining pressure; Unbound materials: soil, aggregate; Bound materials: binding using asphalt, water, lime, polymer, flyash, cement; Constitutive models: unbound materials, bound materials; Field performance of pavement materials: fatigue, rutting, temperature issues, moisture damage, permeability; Transfer functions to relate laboratory performance with field performance.
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15. Lecture Outline *(with topics and number of lectures)*

Module no.	Topic	No. of hours
1	Role of constitutive modeling	1
2	Laboratory testing in relation to constitutive modeling: elastic modulus, resilient modulus, complex modulus, creep, rheological tests	3
3	Introduction to continuum mechanics: strain tensor, stress tensor, isotropy, anisotropy, constitutive relationships	3
4	Factors affecting material behavior: temperature, rate, time, confining pressure	2
5	Unbound materials: soil, aggregate	4
6	Bound materials: binding using asphalt, water, lime, polymer, flyash, cement	4
7	Constitutive models: unbound materials, bound materials	5
8	Field performance of pavement materials: fatigue, rutting, temperature issues, moisture damage, permeability	4
9	Transfer functions to relate laboratory performance with field performance	2
10		
11		
12		
COURSE TOTAL (14 times 'L')		28

16. Brief description of tutorial activities

NA

17. Brief description of laboratory activities

Module no.	Experiment description	No. of hours
1	Characterization of stabilized soil system: mixture design	6
2	Characterization of stabilized soil system: durability tests	4
3	Characterization of bound aggregate system: mixture design	6
4	Characterization of bound aggregate system: durability tests	4
5	Development of constitutive models from laboratory observations and field data	8
6		
7		
8		
9		
10		
COURSE TOTAL (14 times 'P')		28

18. Suggested texts and reference materials

STYLE: Author name and initials, Title, Edition, Publisher, Year.

1. Kim, Y. R., Modeling of Asphalt Concrete, First Edition, McGraw-Hill Professional, 2008.
2. Christensen, R.M., Theory of Viscoelasticity, An Introduction, Second Edition, Academic Press, 2010.
3. Lemaitre, J., and Desmorat, R., Engineering Damage Mechanics, Springer Verlag, 2005.

4. Mitchell, J. K., and Soga. K., Fundamentals of Soil Behavior, John Wiley & Sons, 2005.
5. Hicher and Shao, Constitutive Modeling of Soils and Rocks, John Wiley and sons, 2008.
6. Lubliner, J., Plasticity, Prentice Hall PTR, 1998.

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

19.1	Software	MS Excel, Matlab
19.2	Hardware	Available
19.3	Teaching aides (videos, etc.)	Multimedia projector
19.4	Laboratory	Yes
19.5	Equipment	Equipments available with transportation engineering lab
19.6	Classroom infrastructure	Required
19.7	Site visits	Occassional

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

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

Date:

(Signature of the Head of the Department)

COURSE TEMPLATE

1.	Department /Centre proposing the course	Civil Engineering
2.	Course Title (<i>< 45 characters</i>)	PAVEMENT MATERIALS AND DESIGN OF PAVEMENTS
3.	L-T-P structure	3 - 0 - 2
4.	Credits	4
5.	Course number	CVL740
6.	Status (<i>category for program</i>)	Program core for MTech in Transportation Engineering Open elective for other MTech program
7.	Pre-requisites (course no./title)	MTech: Nil; BTech: Instructor's permission
8.	Status vis-à-vis other courses (<i>give course number/title</i>)	
8.1	Overlap with any UG/PG course of the Dept./Centre	CVL261:20%
8.2	Overlap with any UG/PG course of other Dept./Centre	Nil
8.3	Supercedes any existing course	CEL782 and CEL784
9.	Not allowed for (indicate program names)	
10.	Frequency of offering	☐ Every sem ☒ 1 st sem ☐ 2 nd sem ☐ Either sem
11.	Faculty who will teach the course Dr. Aravind Krishna Swamy Dr. Kalaga Ramachandra Rao Prof. Geetam Tiwari Dr. S. K. Deb	
12.	Will the course require any visiting faculty?	No
13.	Course objective (<i>about 50 words</i>): To provide students with an understanding of fundamentals (historical, theoretical, experimental) related to (i) Characterization of materials used in pavement construction (soil, aggregate, asphalt), (ii) Structural and functional design of pavements.	
14.	Course contents (<i>about 100 words</i>) (<i>Include laboratory/design activities</i>): Components of pavement structure and its requirements; Materials used in pavement construction: aggregate, Portland cement, asphalt, Portland cement concrete, asphalt concrete; Aggregates: production, properties, testing procedures, gradation and blending; Portland cement based materials: mixture design, production, properties, testing, construction; Asphalt binder: refining	

	process, properties, testing procedures, grading systems; Asphalt concrete mixture design: fundamentals of mix design procedure, mixture volumetrics, current mix design procedures; Production and construction practices; Stresses and strains in pavement system: traffic, environment considerations; Design of pavements: new, overlay; Pavement performance; Drainage consideration.
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15. Lecture Outline (*with topics and number of lectures*)

Module no.	Topic	No. of hours
1	Components of pavement structure and its requirements; Materials used in pavement construction: aggregate, Portland cement, asphalt, Portland cement concrete, asphalt concrete	1
2	Aggregates: production, properties, testing procedures, gradation and blending	3
3	Portland cement based materials: mixture design, production, properties, testing, construction	3
4	Asphalt binder: refining process, properties, testing procedures, grading systems	5
5	Asphalt concrete mixture design: fundamentals of mix design procedure, mixture volumetrics, current mix design procedures; Production and construction practices	6
6	Stresses and strains in pavement system: traffic, environment considerations	5
7	Design of pavements: new, overlay	10
8	Pavement performance	8
9	Drainage consideration	1
10		
11		
12		
COURSE TOTAL (14 times 'L')		42

16. Brief description of tutorial activities

NIL

17. Brief description of laboratory activities

Module no.	Experiment description	No. of hours
1	Characterization of aggregate for physical properties	4
2	Characterization of aggregate for durability issues	4
3	Characterization of asphalt binder under unaged condition	4
4	Characterization of asphalt binder under aged condition	4
5	Bituminous mixture design	8
6	Mixture testing for durability	4
7		
8		
9		
10		
COURSE TOTAL (14 times 'P')		28

18. Suggested texts and reference materials

STYLE: Sonntag, R. E., Borgnakke, C., and Van Wylen, G. J., *Fundamentals of Thermodynamics*, 5th Ed., John Wiley, 2000.

1. Roberts, F. L., Kandhal, P. S., Brown, E. R., Lee, D., and Kennedy, T. (1996). Hot Mix Asphalt Materials, Mixture Design and Construction, National Asphalt Pavement Association Research and Education Foundation, MD, USA.

2. Whiteoak, D., and Read, J. (2003). The Shell Bitumen Handbook, Thomas Telford Publishing, UK.
3. Atkins, H.N. Highways Materials, Soils and Concrete Prentice Hall, 1996.
4. Asphalt Institute, Superpave Mix Design, SP-1 and SP-2.
5. Ministry of Road Transport and Highways, 2000, Road Construction and Materials Standards.
6. Neville, Adam M. Properties of concrete. No. Monograph. 1981.
7. Huang, Y., Pavement Analysis and Design, 2004, 2nd edition, Prentice-Hall, Inc.
8. Croney, D. and Croney, P., Design and Performance of Road Pavement, McGraw Hill, 1998.
9. Shahin, M.Y., Pavement Management of Roads, Airports and Parking Lots, Chapman and Hall, 1998.
- 10 Yoder, E.J. and Witczack, M.W. Principles of Pavement Design, 2nd edition, Wiley India, 1975.
11. Thom, N. Principles of Pavement Engineering, ICE Publishing, 2014.
12. Rao, G.V., Rao. K.R., Pahari, K., Bhavanna Rao, D.V., Highway material testing and quality control, IK Publishers, 2015.
13. Das, A. Analysis of Pavement Structures, 1st edition, CRC Press, 2014.

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

19.1	Software	MS Excel, Matlab
19.2	Hardware	
19.3	Teaching aides (videos, etc.)	Multimedia projector
19.4	Laboratory	Required
19.5	Equipment	Equipments available with transportation engineering lab
19.6	Classroom infrastructure	Required
19.7	Site visits	Occassional

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

20.1	Design-type problems	
20.2	Open-ended problems	
20.3	Project-type activity	30%
20.4	Open-ended laboratory work	
20.5	Others (please specify)	

Date:

(Signature of the Head of the Department)

COURSE TEMPLATE

1.	Department /Centre proposing the course	Civil Engineering
2.	Course Title (<i>< 45 characters</i>)	PLANNING AND DESIGN OF SUSTAINABLE TRANSPORT SYSTEMS
3.	L-T-P structure	3 - 0 - 0
4.	Credits	3
5.	Course number	CVL840
6.	Status (<i>category for program</i>)	Program elective for MTech in Transportation Engineering Open elective for other MTech programs

7.	Pre-requisites (course no./title)	MTech: CVL741; BTech: Instructor's permission
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8.	Status vis-à-vis other courses (<i>give course number/title</i>)	
8.1	Overlap with any UG/PG course of the Dept./Centre	Nil
8.2	Overlap with any UG/PG course of other Dept./Centre	Nil
8.3	Supercedes any existing course	Nil

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 Prof. Geetam Tiwari Dr. Kalaga Ramachandra Rao Dr. S. K. Deb Dr. Aravind Krishna Swamy	
12.	Will the course require any visiting faculty?	No

13.	Course objective (<i>about 50 words</i>): The students should be able to : (i) Understand the principles of Sustainable Transport systems, (ii) Appreciate the planning and design considerations for pedestrians, bicycles and public transport systems, (iii) Understand the indicators for measuring transport system sustainability.	
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14.	Course contents (<i>about 100 words</i>) (<i>Include laboratory/design activities</i>): Sustainable Transportation Planning and Design including: Consideration of bicycles, pedestrian, mass transit modes, and private vehicles like cars and two wheelers.as well as how these modes interrelate. Applicability at varying scales, from a downtown street to a neighborhood to a regional network Case	
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	studies are discussed from different parts of the world. Various indicators for measuring sustainability index of transport system including public health, resource consumption, local and global pollution and equity considerations are discussed.
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15. Lecture Outline (*with topics and number of lectures*)

Module no.	Topic	No. of hours
1	Sustainable transport system principles	4
2	Planning and design for pedestrians	6
3	Planning and design for bicycles	6
4	Neighbourhood designs for sustainable transport systems	4
5	Planning and design of accessible public transport systems	6
6	Sustainable transport indicators	8
7	Policies for promoting sustainable transport systems	4
8	Alternate analysis for transport systems	4
9		
10		
11		
12		
COURSE TOTAL (14 times 'L')		42

16. Brief description of tutorial activities

NIL

17. Brief description of laboratory activities

Module no.	Experiment description	No. of hours
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		
COURSE TOTAL (14 times 'P')		

18. Suggested texts and reference materials

STYLE: Sonntag, R. E., Borgnakke, C., and Van Wylen, G. J., *Fundamentals of Thermodynamics*, 5th Ed., John Wiley, 2000.

1. Tumlin ,Jeffery, Sustainable Transportation Planning: Tools for Creating Vibrant, Healthy, and Resilient Communities (Wiley Series in Sustainable Design), 2012.
2. Munier, N. Introduction to Sustainability – Road to a Better Future. Springer, 2005.
3. Banister, D. Unsustainable Transport – City transport in the new century. Routledge, London. 2005.
4. Safety, Sustainability and Future Urban Transport , ed D. Mohan, Eicher Goodearth, New Delhi, India, 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.)	
19.4	Laboratory	
19.5	Equipment	
19.6	Classroom infrastructure	
19.7	Site visits	

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

20.1	Design-type problems	
20.2	Open-ended problems	20%
20.3	Project-type activity	30%
20.4	Open-ended laboratory work	
20.5	Others (please specify)	

Date:

(Signature of the Head of the Department)

COURSE TEMPLATE

1.	Department /Centre proposing the course	Civil Engineering
2.	Course Title (<i>< 45 characters</i>)	PUBLIC TRANSPORTATION SYSTEMS
3.	L-T-P structure	3 - 0 - 0
4.	Credits	3
5.	Course number	CVL746
6.	Status (<i>category for program</i>)	Program elective for MTech in Transportation Engineering Open elective for other MTech programs
7.	Pre-requisites (<i>course no./title</i>)	MTech: Nil; BTech: Instructor's permission
8.	Status vis-à-vis other courses (<i>give course number/title</i>)	
8.1	Overlap with any UG/PG course of the Dept./Centre	10% CEL741
8.2	Overlap with any UG/PG course of other Dept./Centre	Nil
8.3	Supercedes any existing course	Nil
9.	Not allowed for (<i>indicate program names</i>)	
10.	Frequency of offering	☐ Every sem ☐ 1 st sem ☐ 2 nd sem ☒ Either sem
11.	Faculty who will teach the course Prof. Geetam Tiwari Dr. Kalaga Ramachandra Rao Dr. S. K. Deb Dr. Aravind Krishna Swamy	
12.	Will the course require any visiting faculty?	No
13.	Course objective (<i>about 50 words</i>): At the end of the course the student should be able to: (i) To design mass transit operations, (ii) To plan and evaluate mass transit operations, (iii) To be conversant of the existing modes of public transport in India and ways to improve them.	
14.	Course contents (<i>about 100 words</i>) (<i>Include laboratory/design activities</i>): This course discusses the role of urban public transportation modes, focusing on bus and rail systems. Operational and Technological characteristics are described, along with their impacts on capacity, service quality, and cost. Current practice and methods for data collection and analysis,	

	performanceevaluation, route and network design, frequency determination, and vehicle and crew scheduling are covered. Main topics include:Transit System; Estimation of Transit Demand; Route planning techniques; Bus Scheduling; Transit Corridor identification and planning; Mass Transport Management Measures; Integration of Public Transportation Modes. Public transport Infrastructure; Case Studies. Multimodal Transportation Systems.
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15. Lecture Outline *(with topics and number of lectures)*

Module no.	Topic	No. of hours
1	Transit systems introduction	2
2	Mass transit technology options	2
3	Transit demand estimations	4
4	Demand elasticities	2
5	Transit performance indicators	6
6	Transit corridor planning	4
7	Route planning techniques	4
8	Bus scheduling	6
9	Modal integration Public transport infrastructure planning Public transportation safety	6
10	Planning and design of terminals Passenger information systems	4
11	Public transport management Institutional and regulatory framework	2
12	Financing options	2
COURSE TOTAL (14 times 'L')		42

16. Brief description of tutorial activities

NIL

17. Brief description of laboratory activities

Module no.	Experiment description	No. of hours
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		
COURSE TOTAL (14 times 'P')		

18. Suggested texts and reference materials

STYLE: Sonntag, R. E., Borgnakke, C., and Van Wylen, G. J., *Fundamentals of Thermodynamics*, 5th Ed., John Wiley, 2000.

1. Ceder, Avishai. Public Transit Planning and Operation: Theory, Modeling and Practice. Burlington, MA: Elsevier, 2007. ISBN: 9780750661669.
2. Vuchic, Vukan. Urban Transit: Operations, Planning and Economics. New York, NY: Wiley, 2005. ISBN: 9780471632658
3. Simpson, B.J. Urban Public Transport Today, E&FN Spon, London, 1994.

4. Simpson, B.J. City Centre Planning & Public Transport, Van Nostrand Reinhold Ltd., 1988.
5. Tiwari, G.(editor) Urban transport for Growing Cities, Macmillan India Ltd, 2002.
6. Institute of Urban Transport, Public Transport Accessibility Tool Kit, IUT, government of India, Delhi 2013 (www.iutindia.org)

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

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

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

20.1	Design-type problems	
20.2	Open-ended problems	20%
20.3	Project-type activity	40%
20.4	Open-ended laboratory work	
20.5	Others (please specify)	

Date:

(Signature of the Head of the Department)

COURSE TEMPLATE

1.	Department /Centre proposing the course	Civil Engineering
2.	Course Title (<i>< 45 characters</i>)	SPECIAL TOPICS IN TRANSPORTATION ENGINEERING
3.	L-T-P structure	3 - 0 - 0
4.	Credits	3
5.	Course number	CVL851
6.	Status (<i>category for program</i>)	Program elective for MTech in Transportation Engineering Open elective for other MTech programs
7.	Pre-requisites (course no./title)	CVL740 or CVL741 or CVL742 or Instructor's permission
8.	Status vis-à-vis other courses (<i>give course number/title</i>)	
8.1	Overlap with any UG/PG course of the Dept./Centre	Nil
8.2	Overlap with any UG/PG course of other Dept./Centre	Nil
8.3	Supersedes any existing course	
9.	Not allowed for (indicate program names)	Any other MTech program
10.	Frequency of offering	☐ Every sem ☐ 1 st sem ☐ 2 nd sem ☒ Either sem
11.	Faculty who will teach the course Prof. Geetam Tiwari Dr. S. K. Deb Dr. Kalaga Ramachandra Rao Dr. Aravind Krishna Swamy	
12.	Will the course require any visiting faculty?	No
13.	Course objective (<i>about 50 words</i>): This course shall cover advanced topics within transportation engineering area that are not addressed by existing courses.	
14.	Course contents (<i>about 100 words</i>) (<i>Include laboratory/design activities</i>): Course details shall be announced by the instructor at the time of offering of the course. The lectures will be supplemented by reading materials. The assessment will be based on a combination of assignments, quizzes, and term papers and tests.	

15. Lecture Outline *(with topics and number of lectures)*

Module no.	Topic	No. of hours
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		
11		
12		
COURSE TOTAL (14 times 'L')		

16. Brief description of tutorial activities

NIL

17. Brief description of laboratory activities

Module no.	Experiment description	No. of hours
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		
COURSE TOTAL (14 times 'P')		

18. Suggested texts and reference materials

STYLE: Sonntag, R. E., Borgnakke, C., and Van Wylen, G. J., *Fundamentals of Thermodynamics*, 5th Ed., John Wiley, 2000.

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

19.1	Software	
19.2	Hardware	
19.3	Teaching aides (videos, etc.)	
19.4	Laboratory	
19.5	Equipment	

19.6	Classroom infrastructure	
19.7	Site visits	

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

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

Date:

(Signature of the Head of the Department)

COURSE TEMPLATE

1.	Department /Centre proposing the course	Civil Engineering
2.	Course Title (<i>< 45 characters</i>)	TRAFFIC ENGINEERING
3.	L-T-P structure	3 - 0 - 2
4.	Credits	4
5.	Course number	CVL742
6.	Status (<i>category for program</i>)	Program core for MTech in Transportation Engineering Open elective for other MTech program
7.	Pre-requisites (course no./title)	MTech: Nil; BTech: Instructor's permission
8.	Status vis-à-vis other courses (<i>give course number/title</i>)	
8.1	Overlap with any UG/PG course of the Dept./Centre	10% CVL261
8.2	Overlap with any UG/PG course of other Dept./Centre	Nil
8.3	Supercedes any existing course	Nil
9.	Not allowed for (indicate program names)	
10.	Frequency of offering	☐ Every sem ☒ 1 st sem ☐ 2 nd sem ☐ Either sem
11.	Faculty who will teach the course Dr. Kalaga Ramachandra Rao Prof. Geetam Tiwari Dr. S. K. Deb Dr. Aravind Krishna Swamy	
12.	Will the course require any visiting faculty?	NO
13.	Course objective (<i>about 50 words</i>): This course intends to equip the students with the basic concepts of road based traffic engineering analysis and design. At the end of the course, the student would be able to (i) Understand the traffic components and characteristics (ii) Conduct traffic studies (iii) Analyze and design expressway and multi-lane highways (iv) Design and analyze intersections	
14.	Course contents (<i>about 100 words</i>) (<i>Include laboratory/design activities</i>): Introductory concepts of traffic engineering, road user and vehicle characteristics Road way geometric characteristics, traffic stream	

	characteristics, and traffic flow theory basics. Statistical applications in traffic engineering. Traffic data collection methods - speed, volume, travel time and delay studies. Parking studies. Highway safety and statistics. Capacity analysis of freeway and multilane highways - fundamental concepts, freeway segment analysis, two-way highways. Intersections concepts of intersection control, intersection layout, signalization basics, signal timing. Analysis of signals and coordination under undersaturated and oversaturated conditions.
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15. Lecture Outline *(with topics and number of lectures)*

Module no.	Topic	No. of hours
1	Introduction and Road User and Vehicle Characteristics	3
2	Roadways and their Geometric Characteristics	4
3	Traffic Stream Characteristics and traffic flow concepts	2
4	Statistical Applications in Traffic Engineering	4
5	Volume Studies and Characteristics	1
6	Speed, Travel Time and Delay Studies	1
7	Accident Studies, Statistics and Programs	1
8	Capacity Level and Level of Service Analysis for Freeways and Multilane Rural Highways	3
9	Two-Lane, Two-Way Rural Highways Traffic Control for Freeways and Rural Highways	3
10	Introduction to Intersection Control Traffic signs and road markings Uncontrolled intersections, and Channelization Traffic roundabout	2 1 1 1
11	Basic Principles of Intersection Signalization Elements of Intersection Design Analysis and applications of Signalized Intersections Actuated Signal Control and Detection Signal Coordination for Arterials and Networks	1 1
12	Traffic Management Intelligent Transportation Systems (ITS): applications in traffic management and control	
COURSE TOTAL (14 times 'L')		42

16. Brief description of tutorial activities

NIL

17. Brief description of laboratory activities

Module no.	Experiment description	No. of hours
1	Traffic Control Devices inventory	4
2	Travel Time and Delay study	2
3	Spot Speed Studies	2
4	Turning Movements and Peak Hour Factor	2
5	Measurement of Intersection Delay	2
6	Sight Distances and Gap Acceptance	2
7	Saturation Flow rates and Level of Service Analysis	2
8	Parking Study and Pedestrian study	2
9	Application of Poisson distribution	2
10	Pedestrian and bicycle facilities Visit to various traffic facilities in the city	2 2
COURSE TOTAL (14 times 'P')		28

18. Suggested texts and reference materials

STYLE: Sonntag, R. E., Borgnakke, C., and Van Wylen, G. J., *Fundamentals of Thermodynamics*, 5th Ed., John Wiley, 2000.

1. Roess, R.P Prassas, E, and McShane, W., Traffic Engineering, 4th edition, Pearson, 2009
2. Kadiyali, L.R. Traffic Engineering and Transportation Planning, Khanna Publishers, 2000.
3. Salter, R.J. and Hounsell, N.B. Highway Traffic Analysis and Design. Macmillan, 1996
4. Taylor, M.A.P., Young, W., Bonsall, P.W. and Taylor, M.A. Understanding Traffic Systems Ashgate Publishing Company, 2000
5. TRB, Highway Capacity Manual, 2010
6. Slinn, M., Guest, P. and Heimann, P. Traffic Engineering Principles and Practice, Butterworth-Heinmann, 2006
7. Murthy, A.S.N., Mohle, H.R. Transportation Engineering Basics, ASCE Press, 2nd Edition, 2001.

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

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

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

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

Date:

(Signature of the Head of the Department)

COURSE TEMPLATE

1.	Department /Centre proposing the course	Civil Engineering
2.	Course Title (<i>< 45 characters</i>)	TRAFFIC FLOW MODELLING
3.	L-T-P structure	3 - 0 - 0
4.	Credits	3
5.	Course number	CVL849
6.	Status (<i>category for program</i>)	Program elective for MTech in Transportation Engineering Open elective for other MTech programs

7.	Pre-requisites (course no./title)	CVL742
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8.	Status vis-à-vis other courses (<i>give course number/title</i>)	
8.1	Overlap with any UG/PG course of the Dept./Centre	<10% with CVL742
8.2	Overlap with any UG/PG course of other Dept./Centre	Nil
8.3	Supercedes any existing course	Nil

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. Kalaga Ramachandra Rao Prof. Geetam Tiwari Dr. S. K. Deb Dr. Aravind Krishna Swamy	
12.	Will the course require any visiting faculty?	NO

13.	Course objective (<i>about 50 words</i>): This course intends to equip the students with the fundamentals of traffic flow theory. At the end of the course, the student would be able to (i) Understand the traffic flow descriptors and their measurement (ii) Conceptualizing the scale of analysis of traffic models (iii) Model and analyze macroscopic and microscopic traffic models	
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14.	Course contents (<i>about 100 words</i>) (<i>Include laboratory/design activities</i>): Descriptors of traffic flow: Macroscopic and Microscopic, time, space and generalized measurement regions. Cumulative plots. Traffic Flow models - General classification and typology. Macroscopic Flow Models - continuity equation, LWR model, higher order models, numerical schema, Mesoscopic	
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	Flow Models - gas kinetic theory, Microscopic and Submicroscopic Flow Models - car following and lane changing; Pipes and forbes models; General motors-Gazis-Herman-Rothery (GHR) models, Stability analysis, macro-micro bridge. Modelling at Junctions/Intersections; Un-signalized and Signalized; Roundabouts; Pedestrian Modelling - normal and panic movements; variations across infrastrucutre; Simulation - simple and complex traffic conditions
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15. Lecture Outline *(with topics and number of lectures)*

Module no.	Topic	No. of hours
1	Descriptors of traffic flow: Macroscopic and Microscopic	5
2	Traffic Flow models	2
3	Macroscopic Flow Models - Continuity equation - LWR model - Higher order models	2 3 3
4	Mesoscopic Flow Models	2
5	Microscopic and Submicroscopic Flow Models - Pipes and forbes model	5
6	Modelling at Junctions/Intersections	2
7	Un-signalized and Signalized	2
8	Roundabouts	2
9	Pedestrian Modelling	3
10	Simulation	6
11		
12		
COURSE TOTAL (14 times 'L')		42

16. Brief description of tutorial activities

NIL

17. Brief description of laboratory activities

Module no.	Experiment description	No. of hours
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		
COURSE TOTAL (14 times 'P')		

18. Suggested texts and reference materials

STYLE: Sonntag, R. E., Borgnakke, C., and Van Wylen, G. J., *Fundamentals of Thermodynamics*, 5th Ed., John Wiley, 2000.

1. TRB, Traffic Flow Theory: A Monograph, Transportation Research Board, 2001 (Earlier versions 1975, 1964).
2. Daganzo, C.F. Fundamentals of Transportation and Traffic Operations, Pergamon Press, 1997.
3. May, A.D., Traffic Flow Fundamentals, Prentice Hall, 1990.

4. Leutbach, W.J. Introduction to the Theory of Traffic Flow, Springer-Verlag, 1989.
5. Treiber, M. and Kesting, A. Traffic flow Dynamics data, models, and Simulation, Springer Berlin, 2013.
6. Ni, D. Lecture notes in Traffic flow theory, Department of Civil and Environmental Engineering, University of Massachusetts, Amherst , 2012.
7. Gazis, D.C. Traffic Theory, Kluwer Academic Publishers, Boston, 2002.
8. Drew, D.R. Traffic Flow Theory and control, Mc Graw Hill, 1968.
9. Elefteriadou, L. An Introduction of Traffic Flow Theory, Springer, New York. 2014.

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

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

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

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

Date:

(Signature of the Head of the Department)

COURSE TEMPLATE

1.	Department /Centre proposing the course	Civil Engineering
2.	Course Title (<i>< 45 characters</i>)	TRANSPORTATION ECONOMICS
3.	L-T-P structure	3 - 0 - 0
4.	Credits	3
5.	Course number	CVL847
6.	Status (<i>category for program</i>)	Program elective for MTech in Transportation Engineering Open elective for other MTech programs
7.	Pre-requisites (<i>course no./title</i>)	MTech: CVL741; BTech: Instructor's permission
8.	Status vis-à-vis other courses (<i>give course number/title</i>)	
8.1	Overlap with any UG/PG course of the Dept./Centre	10% with CEL779, 10% with CEL866
8.2	Overlap with any UG/PG course of other Dept./Centre	Nil
8.3	Supercedes any existing course	
9.	Not allowed for (<i>indicate program names</i>)	
10.	Frequency of offering	☐ Every sem ☐ 1 st sem ☐ 2 nd sem ☒ Either sem
11.	Faculty who will teach the course Prof. Geetam Tiwari Dr. Kalaga Ramachandra Rao Dr. S. K. Deb Dr. Aravind Krishna Swamy	
12.	Will the course require any visiting faculty?	No
13.	Course objective (<i>about 50 words</i>): At the end of the course the student should be able to: (i) Understand the principles of transportation economics, (ii) Estimate cost of externalities of transport systems, (iii) Understand legal frame work and financing of transport systems, (iv) Understand case studies of transportation projects.	
14.	Course contents (<i>about 100 words</i>) (<i>Include laboratory/design activities</i>): Overview of Transportation Economics; Transportation Investments and economic Development. Basics of Engineering economics, marginal analysis, opportunity cost, shadow price, money value of time, discounted cash flow,	

	NPV, ROR, benefit-cost analysis. Road User Costs; Public transportation economics; Social Cost of Transportation; Cost of congestion, pollution, traffic accidents. Taxation, regulations, financing Transport Systems; Legal framework for transportation sector, case studies
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15. Lecture Outline *(with topics and number of lectures)*

Module no.	Topic	No. of hours
1	Overview Transportation Economics: How the transportation investments are going to benefit/hurt the economy	4
2	Transportation Investments and economic development	4
3	Engineering economics: marginal analysis, shadow price, opportunity costs, time value of money, discounted cash flow NPV, ROR, PI, benefit-cost analysis	6
4	Road User Costs: direct and indirect,	4
5	Value of time, Congestion pricing	6
6	Cost of pollution, traffic Accidents	6
7	Financing Transport Systems	4
8	Public Transportation: Investments and fare subsidy policies	4
9	Legal Framework in Transport Sector: MV Act, NHAI Act, Airport Act, L	4
10		
11		
12		
COURSE TOTAL (14 times 'L')		42

16. Brief description of tutorial activities

NIL

17. Brief description of laboratory activities

Module no.	Experiment description	No. of hours
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		
COURSE TOTAL (14 times 'P')		

18. Suggested texts and reference materials

STYLE: Sonntag, R. E., Borgnakke, C., and Van Wylen, G. J., *Fundamentals of Thermodynamics*, 5th Ed., John Wiley, 2000.

1. Richard de Neufville, Applied Systems Analysis: Engineering Planning and Technology Management, Mcgraw-Hill International Edition.
2. David W. Pearce, R.Kerry Turner, Economics of Natural Resources and the environment, The John Hopkins University Press, USA.
3. Emile Quinet and Roger Vickerman, Principles of Transport Economics, Edward Elgar Publishing 2004.

4. Christopher Nash and Bryan Matthews eds. Measuring the marginal Social Cost of transport, Research in transportation Economics, vol.14, Elsevier, 2005.
5. Small, K.A. Urban Transportation economics, Harwood Academic Publishers, 1992.
6. Jara-Diaz, Sergio, Transport Economic Theory, Elsevier, 2007.

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

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

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

20.1	Design-type problems	
20.2	Open-ended problems	20%
20.3	Project-type activity	30%
20.4	Open-ended laboratory work	
20.5	Others (please specify)	

Date:

(Signature of the Head of the Department)

COURSE TEMPLATE

1.	Department /Centre proposing the course	Civil Engineering
2.	Course Title (<i>< 45 characters</i>)	TRANSPORTATION INFRASTRUCTURE DESIGN
3.	L-T-P structure	2 - 0 - 2
4.	Credits	3
5.	Course number	CVL744
6.	Status (<i>category for program</i>)	Program elective for MTech in Transportation Engineering Open elective for other MTech programs
7.	Pre-requisites (<i>course no./title</i>)	MTech: NIL; BTech: Instructor's permissio
8.	Status vis-à-vis other courses (<i>give course number/title</i>)	
8.1	Overlap with any UG/PG course of the Dept./Centre	Nil
8.2	Overlap with any UG/PG course of other Dept./Centre	Nil
8.3	Supercedes any existing course	
9.	Not allowed for (<i>indicate program names</i>)	
10.	Frequency of offering	☐ Every sem ☐ 1 st sem ☐ 2 nd sem ☒ Either sem
11.	Faculty who will teach the course Dr. S. K. Deb Dr. Aravind Krishna Swamy Dr. Kalaga Ramachandra Rao Prof. Geetam Tiwari	
12.	Will the course require any visiting faculty?	Nil
13.	Course objective (<i>about 50 words</i>): At the end of the course the student should be able to conceptualise and design of transportation infrastructure. Key issues includes (i) Structural design, (ii) Functional design, (iii) Project implementation and maintenance .	
14.	Course contents (<i>about 100 words</i>) (<i>Include laboratory/design activities</i>): Transportation infrastructure: components, structural and functional requirements, capacity, level of service; Highway infrastructure: grade intersections, rotaries, interchanges; Railway infrastructure: trackbed design, grade-crossing design, embankment, retaining walls; Drainage infrastructure:	

	culverts, bridges; Pedestrian infrastructure: pedestrian sideways, foot bridges; Miscellaneous: bus and truck terminals, parking facilities, guard rails, tunnels, underpasses;.
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15. Lecture Outline *(with topics and number of lectures)*

Module no.	Topic	No. of hours
1	Transportation infrastructure: components, structural and functional requirements, capacity, level of service;	4
2	Highway infrastructure: grade intersections	3
3	Highway infrastructure: grade rotaries, interchanges;	3
4	Railway infrastructure: trackbed design, grade-crossing design, embankment, retaining walls;	5
5	Drainage infrastructure: culverts, bridges;	4
6	Pedestrian infrastructure: pedestrian sidewalks, foot bridges;	4
7	Miscellaneous: bus and truck terminals, parking facilities	3
8	Miscellaneous: guard rails, tunnels, underpasses;	2
9		
10		
11		
12		
COURSE TOTAL (14 times 'L')		28

16. Brief description of tutorial activities

NIL

17. Brief description of laboratory activities

Module no.	Experiment description	No. of hours
1	Highway infrastructure: grade intersections, rotaries, interchanges;	4
2	Highway infrastructure: grade intersections, rotaries, interchanges;	6
3	Railway infrastructure: trackbed design, grade-crossing design, embankment, retaining walls;	4
4	Drainage infrastructure: culverts, bridges;	4
5	Pedestrian infrastructure: pedestrian sidewalks, foot bridges;	4
6	Miscellaneous: bus and truck terminals, parking facilities, guard rails, tunnels, underpasses;	6
7		
8		
9		
10		
COURSE TOTAL (14 times 'P')		28

18. Suggested texts and reference materials

STYLE: Sonntag, R. E., Borgnakke, C., and Van Wylen, G. J., *Fundamentals of Thermodynamics*, 5th Ed., John Wiley, 2000.

1. Ponnuswamy, S., Bridge Engineering, Tata McGraw Hill Publishing Company Limited, New Delhi, 1990.
2. Jack E. Leisch Associates At Grade Intersections, Planning And Design Guide, 1981.
3. Chrest, A.P., Smit, M.S. and Bhuyan, S. Parking Structures Planning, Design, Construction, Maintenance and Repair, Van Nostrand Reinhold, New York, 1989.

4. Underwood, R.T. Geometric Design of Highways, McMillan, 1996
5. Munday, J.S., Railway Track Engineering, Tata McGraw Hill, New Delhi, 2011.
6. Hay, W. W., Railroad Engineering, John Wiley and Sons, New York, 1988.
7. Bonnett, C.F., Practical Railway Engineering, Imperial College Press, 2005.

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

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

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

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

Date:

(Signature of the Head of the Department)

COURSE TEMPLATE

1.	Department /Centre proposing the course	Civil Engineering
2.	Course Title (<i>< 45 characters</i>)	TRANSPORTATION INFRASTRUCTURE MANAGEMENT
3.	L-T-P structure	2 - 0 - 2
4.	Credits	3
5.	Course number	CVL844
6.	Status (<i>category for program</i>)	Program elective for MTech in Transportation Engineering Open elective for other MTech programs

7.	Pre-requisites (<i>course no./title</i>)	MTech: CVL740; BTech: Instructor's permission
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8.	Status vis-à-vis other courses (<i>give course number/title</i>)	
8.1	Overlap with any UG/PG course of the Dept./Centre	Nil
8.2	Overlap with any UG/PG course of other Dept./Centre	Nil
8.3	Supercedes any existing course	

9.	Not allowed for (<i>indicate program names</i>)	
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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. Aravind Krishna Swamy Dr. Kalaga Ramachandra Rao Prof. Geetam Tiwari Dr. S. K. Deb	
12.	Will the course require any visiting faculty?	No

13.	Course objective (<i>about 50 words</i>): To provide students with an understanding of (i) Detrioration mechanisms in transportaiton infrastructure, (ii) Identify and collect relavent information, (iii) Develop prioritization/optimization methods to manage the transportaion infrastructure.	
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14.	Course contents (<i>about 100 words</i>) (<i>Include laboratory/design activities</i>): Transportation infrastructure components; Deterioration phemomena; Effect of external factors like environment, traffic loading, material properties on deterioration mechanisms; Evaluation techniques to evaluate damage: destructive, nondestructive; Performance models: development, calibration;	
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	Infrastructure management systems; Serviceability of condition and safety; Decision making and optimization techniques applied to infrastructure management; Life cycle cost analysis techniques.
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15. Lecture Outline *(with topics and number of lectures)*

Module no.	Topic	No. of hours
1	Transportation infrastructure components	2
2	Deterioration phenomena; Effect of external factors like environment, traffic loading, material properties on deterioration mechanisms	5
3	Evaluation techniques to evaluate damage: destructive, nondestructive	5
4	Performance models: development, calibration	3
5	Infrastructure management systems	4
6	Serviceability of condition and safety	3
7	Decision making techniques applied to infrastructure management	3
8	Life cycle cost analysis techniques	3
9		
10		
11		
12		
COURSE TOTAL (14 times 'L')		28

16. Brief description of tutorial activities

NA

17. Brief description of laboratory activities

Module no.	Experiment description	No. of hours
1	Evaluation of transportation materials through destructive testing	8
2	Evaluation of transportation materials through nondestructive testing	6
3	Development and calibration of deterioration models using experimental, field data	4
4	Life cycle cost analysis	6
5	Optimization models development	4
6	NA	
7	NA	
8	NA	
9	NA	
10	NA	
COURSE TOTAL (14 times 'P')		28

18. Suggested texts and reference materials

STYLE: Author name and initials, Title, Edition, Publisher, Year.

1. Hass, R., Hudson, W.R. and Zaniewski, J., "Modern Pavement Management", Krieger. 1994
2. Fwa, T.F., "The Hand Book of Highway Engineering", CRC Press, Taylor & Francies Group. 2006
3. Shain, M.Y., "Pavement Management for Airports, Roads and Parking Lots", Kluwer Academic Publishers Group. 2004
4. Hudson, W.R., Haas, R. and Uddin, W., "Infrastructure Management", McGraw Hill. 1997
5. Hass, R. and Hudson, W.R., "Pavement Management System", McGraw Hill Company,

Inc. 1978

6. Kumares C. Sinha, Samuel Labi, Transportation Decision Making: Principles of Project Evaluation and Programming, Wiley, 2007
7. S. S. Rao, Engineering Optimization: Theory and Practice, Wiley & Sons, New Jersey, 2009.

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

19.1	Software	MS Excel, Matlab
19.2	Hardware	Nil
19.3	Teaching aides (videos, etc.)	Laptop, Multimedia projector
19.4	Laboratory	Nil
19.5	Equipment	Yes
19.6	Classroom infrastructure	Multimedia projector
19.7	Site visits	Nil

20. Design content 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 activity	
20.4	Open-ended laboratory work	
20.5	Others (please specify)	

Date:

(Signature of the Head of the Department)

COURSE TEMPLATE

1.	Department /Centre proposing the course	Civil Engineering
2.	Course Title (<i>< 45 characters</i>)	TRANSPORTATION LOGISTICS
3.	L-T-P structure	3 - 0 - 0
4.	Credits	3
5.	Course number	CVL850
6.	Status (<i>category for program</i>)	Program elective for MTech in Transportation Engineering Open elective for other MTech program
7.	Pre-requisites (<i>course no./title</i>)	MTech: CVL742 else Instructor's permission (including BTech)
8.	Status vis-à-vis other courses (<i>give course number/title</i>)	
8.1	Overlap with any UG/PG course of the Dept./Centre	no
8.2	Overlap with any UG/PG course of other Dept./Centre	SML843 Supply chain logistics management (~30%)
8.3	Supercedes any existing course	
9.	Not allowed for (<i>indicate program names</i>)	
10.	Frequency of offering	☐ Every sem ☐ 1 st sem ☐ 2 nd sem ☒ Either sem
11.	Faculty who will teach the course Dr. Kalaga Ramachandra Rao Prof. Geetam Tiwari Dr. Aravind krishna Swamy Dr. S. K. Deb	
12.	Will the course require any visiting faculty?	No
13.	Course objective (<i>about 50 words</i>): The objectives of this course are: (i) To understand the freight movement at different levels (city, state, nation) from engineering perspective, (ii) To understand fundamentals of supply chain (iii) To understand impact of freight movements on transportation networks (iv) to understand city logistics and its impact on travel patterns of the city.	
14.	Course contents (<i>about 100 words</i>) (<i>Include laboratory/design activities</i>): Evolution of freight and logistics; Interrelationships between society,	

	environment and freight transport; Survey methodologies to understand freight movement; Cost measurement: Production, Holding, Transportation, Handling; Effect of internal and external variables on cost; Demand forecasting; Inventory planning and management; Transportation and distribution network: Design, Reverse Logistics. Development, Management; Ware house operations; Pricing: Perishable, seasonal demand, uncertainty issues; Vehicle routing: One-to-one distribution, One-to-many distribution, Shortest path algorithm, Quickest time algorithm; Logistics information system; Designing and planning transportation networks; City logistics
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15. Lecture Outline (*with topics and number of lectures*)

Module no.	Topic	No. of hours
1	Introduction and Evolution of freight and logistics	3
2	Interrelationships between society, environment and freight transport;	4
3	Survey methodologies to understand freight movement	4
4	Cost measurement: Production, Holding, Transportation, Handling; Effect of internal and external variables on cost Reverse logistics	2 2
5	Demand forecasting; Inventory planning and management	5
6	Designing and planning transportation networks: Design, Development, Management	4
7	Ware house operations; Pricing: Perishable, seasonal demand, uncertainty issues	3
8	Vehicle routing: One-to-one distribution, One-to-many distribution, Shortest path algorithm, Quickest time algorithm	5
9	Logistics information system;	4
10	City logistics	3
11	Applied techniques in city logistics	3
12		
COURSE TOTAL (14 times 'L')		42

16. Brief description of tutorial activities

NIL

17. Brief description of laboratory activities

Module no.	Experiment description	No. of hours
1	NA	
2	NA	
3	NA	
4	NA	
5	NA	
6	NA	
7	NA	
8	NA	
9	NA	
10	NA	
COURSE TOTAL (14 times 'P')		

18. Suggested texts and reference materials

STYLE: Sonntag, R. E., Borgnakke, C., and Van Wylen, G. J., *Fundamentals of Thermodynamics*, 5th Ed., John Wiley, 2000.

1. Daganzo, C.F. Logistics Systems Analysis, 4th edition, Springer, Berlin, 2005.
2. Frazelle, E.H. Supply chain strategy, Tata McGraw Hill, 2004.
3. Chopra, S., Meindl, P., Kalra, D.V. Supply chain management: strategy, planning and operations, 4th edition, Pearson, 2010.

4. Taiguchi, E., City Logistics: Modelling, planning and evaluation, CRC Press, 2015.

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

19.1	Software	MS Excel, Matlab
19.2	Hardware	NIL
19.3	Teaching aides (videos, etc.)	OHP, Laptop, Multimedia projector
19.4	Laboratory	NIL
19.5	Equipment	NIL
19.6	Classroom infrastructure	~75 students
19.7	Site visits	

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

20.1	Design-type problems	5
20.2	Open-ended problems	5
20.3	Project-type activity	10
20.4	Open-ended laboratory work	
20.5	Others (please specify)	

Date:

(Signature of the Head of the Department)

COURSE TEMPLATE

1.	Department /Centre proposing the course	Civil Engineering
2.	Course Title (<i>< 45 characters</i>)	TRAFFIC SAFETY & ENVIRONMENT
3.	L-T-P structure	3 - 0 - 0
4.	Credits	3
5.	Course number	CVL747
6.	Status (<i>category for program</i>)	Program elective for MTech in Transportation Engineering Open elective for other MTech programs
7.	Pre-requisites (<i>course no./title</i>)	MTech: Nil; BTech: Instructor's permission
8.	Status vis-à-vis other courses (<i>give course number/title</i>)	
8.1	Overlap with any UG/PG course of the Dept./Centre	Nil
8.2	Overlap with any UG/PG course of other Dept./Centre	Nil
8.3	Supercedes any existing course	CEL787
9.	Not allowed for (<i>indicate program names</i>)	
10.	Frequency of offering	☐ Every sem ☐ 1 st sem ☐ 2 nd sem ☒ Either sem
11.	Faculty who will teach the course Prof. Geetam Tiwari Dr. Kalaga Ramachandra Rao Dr. S. K. Deb Dr. Aravind Krishna Swamy	
12.	Will the course require any visiting faculty?	Yes
13.	Course objective (<i>about 50 words</i>): (i) Understand highway safety as a complex multidisciplinary system, (ii) Understand the institutional settings in which safety management decisions are made, (iii) Identify potential countermeasures linked to the contributing factors, (iv) Apply countermeasures with promise of crash and injury reduction, and implement and evaluate the effectiveness of the countermeasures, (v) Develop expertise in analysis of emissions and pollution caused by traffic.	
14.	Course contents (<i>about 100 words</i>) (<i>Include laboratory/design activities</i>): Scientific management techniques in planning, implementing, and evaluating highway safety programs., strategies to integrate and amplify safety in	

	transportation planning processes., multidisciplinary relationships necessary to support effective traffic safety initiatives.Traffic Safety as public health problem, Injury indices and costing , emergency care, pollution inventory in urban areas, environment and safety standards.
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15. Lecture Outline *(with topics and number of lectures)*

Module no.	Topic	No. of hours
1	International overview	2
2	Road Traffic Injuries in India	2
3	Injury as a disease, Energy principles, Haddons Matrix	4
4	Risk perception, probability, Indices and Indicators	4
5	Education, training, policing, penalties	4
6	Speed and traffic calming, urban roads	4
7	Highways, junctions	4
8	Injury Scoring, cost of crashes	3
9	Bicycle, motorcycle, motor vehicle, bus safety and ITS	5
10	Pollution Inventory & Assessment Tools, Health effects of transport. sustainable transport Interventions	5
11	Emergency care	2
12	Institutions and management of traffic safety	3
COURSE TOTAL (14 times 'L')		42

16. Brief description of tutorial activities

NIL

17. Brief description of laboratory activities

Module no.	Experiment description	No. of hours
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		
COURSE TOTAL (14 times 'P')		

18. Suggested texts and reference materials

STYLE: Sonntag, R. E., Borgnakke, C., and Van Wylen, G. J., *Fundamentals of Thermodynamics*, 5th Ed., John Wiley, 2000.

1. Hauer, E., *The Art of Regression Modeling in Road Safety*, Springer, 2015
2. Hauer, E., *Observational Before-After Studies in Road Safety*, Emerald Group Publishing Limited, 1997.
3. Tiwari, G., Mohan, D. and Muhlrad, N.(eds) *The Way Forward: Transportation Planning and Road Safety*. New Delhi: Macmillan India Ltd., 2005.
4. Paul Olson and Robert Dewar (2007) *Human Factors in Traffic Safety*. Amazon Digital.
5. Peden, M., et al. *World Report on Road Traffic Injury Prevention*. World Health

Organization, Geneva, 2004.

6. Robin Hickman and David Banister. Transport, Climate Change and the City. Routledge, London, 2014.

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

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

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

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

Date:

(Signature of the Head of the Department)

COURSE TEMPLATE

1.	Department /Centre proposing the course	Civil Engineering
2.	Course Title (<i>< 45 characters</i>)	TRANSPORTATION SYSTEM MANAGEMENT
3.	L-T-P structure	3 - 0 - 0
4.	Credits	3
5.	Course number	CVL846
6.	Status (<i>category for program</i>)	Program elective for MTech in Transportation Engineering Open elective for other MTech programs
7.	Pre-requisites (<i>course no./title</i>)	MTech: CVL741 and CVL742; BTech: Instructor's permission
8.	Status vis-à-vis other courses (<i>give course number/title</i>)	
8.1	Overlap with any UG/PG course of the Dept./Centre	Nil
8.2	Overlap with any UG/PG course of other Dept./Centre	Nil
8.3	Supercedes any existing course	
9.	Not allowed for (<i>indicate program names</i>)	
10.	Frequency of offering	☐ Every sem ☐ 1 st sem ☐ 2 nd sem ☒ Either sem
11.	Faculty who will teach the course Dr. Kalaga Ramachandra Rao Prof. Geetam Tiwari Dr. S. K. Deb Dr. Aravind Krishna Swamy	
12.	Will the course require any visiting faculty?	No
13.	Course objective (<i>about 50 words</i>): At the end of the course the student should be able to: (i) Identify current and emerging challenges and opportunities facing transport, (ii) Link programs and projects to strategic transport outcomes, (iii) To understand available transport funding sources, (iv) Find ways to utilise roads and railways for people and freight movement, (v) Understanding the transport impacts of greenfield and infill developments.	
14.	Course contents (<i>about 100 words</i>) (<i>Include laboratory/design activities</i>): Transportation systems - resource management, approaches to funding. Asset and demand management - Integrated network design, changing travel	

	behaviour, optimising asset management, role of technology; Optimizing the investment outcomes - movement of freight and passenger traffic. Land use planning and urban growth management - land use and its effect on infrastructure and efficient network operations. congestion, systemic congestion improvement and system-wide efficiency, Transit oriented development, safety considerations; evaluation of strategies; case studies.
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15. Lecture Outline *(with topics and number of lectures)*

Module no.	Topic	No. of hours
1	Transportation systems -resource management, approaches to funding.	3
2	Asset and demand management - Integrated network design, changing travel behaviour, optimising asset management, role of technology	2 2 2
3	Optimizing the investment outcomes - movement of freight and passenger traffic	4
4	Land use planning and urban growth management	4
5	Land use and its effect on infrastructure and efficeint network operations. Understand the transport impacts of greenfield and infill developments	3 2
6	Congestion,systemic congestion improvement and system-wide efficiency	4
7	Safety considerations; evaluation of strategies; case studies.	3
8	TSM strategies - urban netowrk operations improvement	5
9	Speed limit management	4
10	Sustainable asset management	3
11	Case studies	3
12		
COURSE TOTAL (14 times 'L')		42

16. Brief description of tutorial activities

NIL

17. Brief description of laboratory activities

Module no.	Experiment description	No. of hours
1	NA	
2	NA	
3	NA	
4	NA	
5	NA	
6	NA	
7	NA	
8	NA	
9	NA	
10	NA	
COURSE TOTAL (14 times 'P')		

18. Suggested texts and reference materials

STYLE: Sonntag, R. E., Borgnakke, C., and Van Wylen, G. J., *Fundamentals of Thermodynamics*, 5th Ed., John Wiley, 2000.

1. USDOT, The Role of Transportation Systems Management & Operations in Supporting Livability and Sustainability: A Primer, US Department of Transportation, 2013.
2. Keyani, Bl. (Transportation system management : state of the art: Volume 1, 1977.

3. Keyani, B.I. Transportation system management : state of the art: Volume 2, University of Michigan, 1977.
4. Hiroaki Suzuki, H., Murakami, J., Hong, Y., Tamayose, B. Financing Transit-Oriented Development with Land Values: Adapting Land Value Capture in Developing Countries, World Bank Publications, 2015.
5. Ewing, R. and Bartholomew, K., Pedestrian- and Transit-Oriented Design, Urban Land Institute, 2013.
6. Altoon, R.A. and Auld, J.C., Urban Transformations: Transit Oriented Development & The Sustainable City, Images Publishing Dist, 2011.

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

19.1	Software	MS Excel, Matlab
19.2	Hardware	NIL
19.3	Teaching aides (videos, etc.)	OHP, Laptop, Multimedia projector
19.4	Laboratory	NIL
19.5	Equipment	NIL
19.6	Classroom infrastructure	multimedia projector
19.7	Site visits	

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

20.1	Design-type problems	5
20.2	Open-ended problems	5
20.3	Project-type activity	20
20.4	Open-ended laboratory work	
20.5	Others (please specify)	

Date:

(Signature of the Head of the Department)

COURSE TEMPLATE

1.	Department /Centre proposing the course	Civil Engineering
2.	Course Title (<i>< 45 characters</i>)	URBAN AND REGIONAL TRANSPORTATION PLANNING
3.	L-T-P structure	3 - 0 - 2
4.	Credits	4
5.	Course number	CVL741
6.	Status (<i>category for program</i>)	Program core for MTech in Transportation Engineering

7.	Pre-requisites (<i>course no./title</i>)	MTech: Nil; BTech: Instructor's permission
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8.	Status vis-à-vis other courses (<i>give course number/title</i>)	
8.1	Overlap with any UG/PG course of the Dept./Centre	20% with CVL261
8.2	Overlap with any UG/PG course of other Dept./Centre	Nil
8.3	Supercedes any existing course	

9.	Not allowed for (<i>indicate program names</i>)	
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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. Geetam Tiwari Dr. Kalaga Ramachandra Rao Dr. S. K. Deb Dr. Aravind Krishna Swamy	
12.	Will the course require any visiting faculty?	No

13.	Course objective (<i>about 50 words</i>): (i) Introduction to all aspects of urban transport model, (ii) Introduce transportation systems analysis of a multimodal integrated urban and regional transport system, (iii) Appreciation of interdependence of travel demand on transport infrastructure and land use patterns, differences in short term impact versus long term changes, (iv) Familiarize the students with the current urban transport problems and policies in India.	
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14.	Course contents (<i>about 100 words</i>) (<i>Include laboratory/design activities</i>): Fundamentals of transportation planning. Components of transportation	
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	system and their interaction. Historical development and current status of techniques used in travel demand forecasting; Economic Theory of travel demand forecasting; trip generation, trip distribution, mode choice, traffic assignment models. Integration of landuse transport models. Comparison and evaluation of various models. Simultaneous travel demand models: Parameter Estimation and Validation. Travel Data collection and use of surveys. The role of transportation planning in the overall regional system. Methodology and models for regional transportation system, planning, implementation framework and case studies. Applications to passenger and freight movement in urban area. Implications for policy formulations and analysis.
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15. Lecture Outline (with topics and number of lectures)

Module no.	Topic	No. of hours
1	Urban Transport Scenario in India and World Cities	2
2	Fundamentals of transportation planning	4
3	Components of transportation system and their interaction	4
4	Historical development and current status of techniques used in travel demand forecasting; Economic Theory of travel demand and elasticity	4
5	Trip generation, trip distribution, mode choice, traffic assignment	6
6	The planning process and use, and transport system models, Comparison and evaluation of various models	4
7	Simultaneous travel demand models: Parameter Estimation and Validation	4
8	Transportation impact study methodologies.	4
9	Regional analysis and development concepts.	2
10	Data collection and use of surveys.	4
11	The role of transportation planning in the overall regional system.	2
12	Methodology and models for regional transportation system, planning, implementation framework and case studies.	2
COURSE TOTAL (14 times 'L')		42

16. Brief description of tutorial activities

NIL

17. Brief description of laboratory activities

Module no.	Experiment description	No. of hours
1	Laboratory Experiments: Planning data case studies I (Household surveys)	2
2	Planning data case studies II (travel surveys)	2
3	Statistical Models for data analyses	2
4	Statistical Models for data Analysis	4
5	Macroscopic models I (TRANSCAD) Data preparation	4
6	Macroscopic models I (TRANSCAD) Modeling	6
7	Macroscopic models II (EMME II etc)	4
8	GIS platform based applications (ARC View, ARC Info, MAP Info)	4
9		
10		
COURSE TOTAL (14 times 'P')		28

18. Suggested texts and reference materials

STYLE: Sonntag, R. E., Borgnakke, C., and Van Wylen, G. J., *Fundamentals of Thermodynamics*, 5th Ed., John Wiley, 2000.

1. Ortuzar, J.D. and Willhumsen, L.G. *Modelling Transport*, 4th edition John Wiley, 2011.
2. Washington, Simon P, Karlaftis, Matthew G, and Mannering, Fred, *Statistical and Econometric Methods for Transportation Data Analysis* Chapman and hall/CR, 2003.
3. Hensher David A, Rose, John M, and Greene, William, H, *Applied Choice Analysis, A Primer*, cambridge University press, 2005.

4. Hensher, David A, Kenneth Button, Handbook of Transport Modelling, Pergamon Press, 2000.
5. Sheffi, Yosef, Urban Transportation networks:Equilibrium Analysis with Mathematical Programming methods, Prentice Hall, 1985.
6. Roy Thomas Traffic Assignment Techniques, Published by Gower Publishing Company, USA, 1991.
7. Michael Patriksson The Traffic Assignment Problem Models and Methods, 1994.
8. Allan Black, Urban Mass Transportation Planning, McGraw Hill, 1995.
9. Oppenheim, N, Urban Travel Demand Modeling: From Individual Choices to General Equilibrium, John Wiley, 1995.
10. Manheim, M.L. Fundamentals of Transportation Systems Analysis. Vol 1. The MIT Press, Cambridge, Massachusetts, 1979.
11. Papacostas, C.S. and Perverdourous, P.V. Transportation Engineering and Planning, Prentice Hall, 2001.
12. Kadiyali, L.R. Traffic Engineering and Transportation Planning, Khanna Publishers, 2000.

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

19.1	Software	TRANSCAD,CUBE , VISSUM, ARC GIS, SPSS
19.2	Hardware	
19.3	Teaching aides (videos, etc.)	Video
19.4	Laboratory	Computer lab
19.5	Equipment	
19.6	Classroom infrastructure	Multi media projector
19.7	Site visits	

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

20.1	Design-type problems	
20.2	Open-ended problems	10%, Review of Urban transport in India
20.3	Project-type activity	30% Three mini projects based on lab work.Report and presentation in groups.
20.4	Open-ended laboratory work	10% Exploring different softwares.
20.5	Others (please specify)	Paper review of a published paper.

Date:

(Signature of the Head of the Department)

COURSE TEMPLATE

1.	Department /Centre proposing the course	Civil Engineering
2.	Course Title (<i>< 45 characters</i>)	VISCOELASTIC BEHAVIOR OF BITUMINOUS MATERIALS
3.	L-T-P structure	3 - 0 - 0
4.	Credits	3
5.	Course number	CVL845
6.	Status (<i>category for program</i>)	Program elective for MTech in Transportation Engineering Open elective for other MTech programs

7.	Pre-requisites (<i>course no./title</i>)	MTech: CVL740; BTech: Instructor's permission
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8.	Status vis-à-vis other courses (<i>give course number/title</i>)	
8.1	Overlap with any UG/PG course of the Dept./Centre	Nil
8.2	Overlap with any UG/PG course of other Dept./Centre	Nil
8.3	Supercedes any existing course	

9.	Not allowed for (<i>indicate program names</i>)	
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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. Aravind Krishna Swamy Dr. Abhijit Ganguli Dr. Kalaga Ramachandra Rao Prof. Geetam Tiwari Dr. S. K. Deb	
12.	Will the course require any visiting faculty?	No

13.	Course objective (<i>about 50 words</i>): (i) To introduce some theories in mechanics that govern the time dependent behavior of bituminous materials, (ii) To understand linear and nonlinear viscoelasticity, fracture mechanics, and continuum damage mechanics, (iii) To discuss physical implications of basic principles through the analysis of experimental data and simulation techniques.	
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14.	Course contents (<i>about 100 words</i>) (<i>Include laboratory/design activities</i>): Overview of material behavior-elastic, plastic, viscoelastic, Viscoplastic response; Aging; Issues in representative volume element; Mechanical analogs for viscoelastic response; Fundamental viscoelastic response-creep	
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	compliance, relaxation, complex modulus; Interconversion techniques to obtain fundamental viscoelastic responses; Time-temperature superposition; linear viscoelastic constitutive equations; Elastic-viscoelastic correspondence principle; Predicting material behavior-undamaged, damaged state conditions, Introduction to nonlinear viscoelasticity, Viscoelastoplastic behavior, fracture mechanics.
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15. Lecture Outline *(with topics and number of lectures)*

Module no.	Topic	No. of hours
1	Overview of material behavior-elastic, plastic, viscoelastic, Viscoplastic response	3
2	Aging	2
3	Issues in representative volume element	2
4	Mechanical analogs for viscoelastic response	5
5	Fundamental viscoelastic response-creep compliance, relaxation, complex modulus	4
6	Interconversion techniques to obtain fundamental viscoelastic responses	4
7	Time-temperature superposition	3
8	Linear viscoelastic constitutive equations-hereditary integral, Boltzmann's superposition integral	5
9	Elastic-viscoelastic correspondence principle	3
10	Predicting material behavior-undamaged, damaged state conditions	4
11	Modeling nonlinear viscoelasticity, viscoelastoplasticity	4
12	Introduction to fracture mechanics	3
COURSE TOTAL (14 times 'L')		42

16. Brief description of tutorial activities

NA

17. Brief description of laboratory activities

Module no.	Experiment description	No. of hours
1	NA	
2	NA	
3	NA	
4	NA	
5	NA	
6	NA	
7	NA	
8	NA	
9	NA	
10	NA	
COURSE TOTAL (14 times 'P')		

18. Suggested texts and reference materials

STYLE: Author name and initials, Title, Edition, Publisher, Year.

1. Christensen, R.M., Theory of Viscoelasticity, An Introduction, Second Edition, Academic Press, 2010.
2. Broek, D., Elementary Engineering Fracture Mechanics. Third Edition, Martinus Nijhoff Publishers, 1982.
3. Lemaitre, J., and Desmorat, R., Engineering Damage Mechanics, Springer Verlag, 2005.
4. Kim, Y. R., Modeling of Asphalt Concrete, First Edition, McGraw-Hill Professional, 2008.

5. Lakes, R., Viscoelastic Materials, Cambridge University Press, 2009.

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

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

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

20.1	Design-type problems	
20.2	Open-ended problems	10
20.3	Project-type activity	10
20.4	Open-ended laboratory work	
20.5	Others (please specify)	15 (Programming)

Date:

(Signature of the Head of the Department)