Program Name : **Civil Engineering Program Group**

Program Code : **CE/CR/CS**

Semester : **Sixth**

Course Title : **Advanced Design of Structures (Elective-II)**

Course Code : **22607**

1. RATIONALE

A Civil Engineering technologist needs to understand the behaviour of various structural components for developing insight for the design concept. Advanced Design of Structures is the core subject for the Civil Engineering which comprises of knowhow of Analysis and Design concept of Steel and Reinforced Concrete structures. For the design of steel components, the properties of steel, available sections, grades and strength characteristics are used along with IS: 800-2007. In the design of RCC structures Limit State Method is to be used as per IS: 456-2000 for analysis and design and IS: 875-1987 is to be used for Loading Standards.

2. COMPETENCY

The aim of this course is to help the student to attain the following industry identified competency through various teaching learning experiences:

- **Design Steel and RCC structural components using relevant software.**

3. COURSE OUTCOMES (COs)

The theory, practical experiences and relevant soft skills associated with this course are to be taught and implemented, so that the student demonstrates the following ***industry oriented*** COs associated with the above mentioned competency:

a) Design the steel tension members under different loading conditions.
b) Design the steel compression members under different loading conditions.
c) Design the doubly-reinforced rectangular RCC beams under different loading conditions.
d) Design the Flanged RCC beams under different loading conditions.
e) Design waist slabs of RCC dog legged staircase.
f) Design the circular columns and the isolated RCC rectangular column footings.

4. TEACHING AND EXAMINATION SCHEME

Teaching Scheme			Credit (L+T+P)	Examination Scheme											
				Theory							Practical				
L	T	P		Paper Hrs.	ESE		PA		Total		ESE		PA		Total	
					Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min
3	-	2	5	4	70	28	30*	00	100	40	25#	10	25	10	50	20

(*): Under the theory PA; Out of 30 marks, 10 marks of theory PA are for micro-project assessment to facilitate integration of COs and the remaining 20 marks is the average of 2 tests to be taken during the semester for the assessment of the UOs required for the attainment of the COs.

***Legends: L**-Lecture; **T** – Tutorial/Teacher Guided Theory Practice; **P** - Practical; **C** – Credit, **ESE** - End Semester Examination; **PA** - Progressive Assessment.*

5. COURSE MAP (with sample COs, PrOs, UOs, ADOs and topics)

This course map illustrates an overview of the flow and linkages of the topics at various levels of outcomes (details in subsequent sections) to be attained by the student by the end of the course, in all domains of learning in terms of the industry/employer identified competency depicted at the centre of this map.

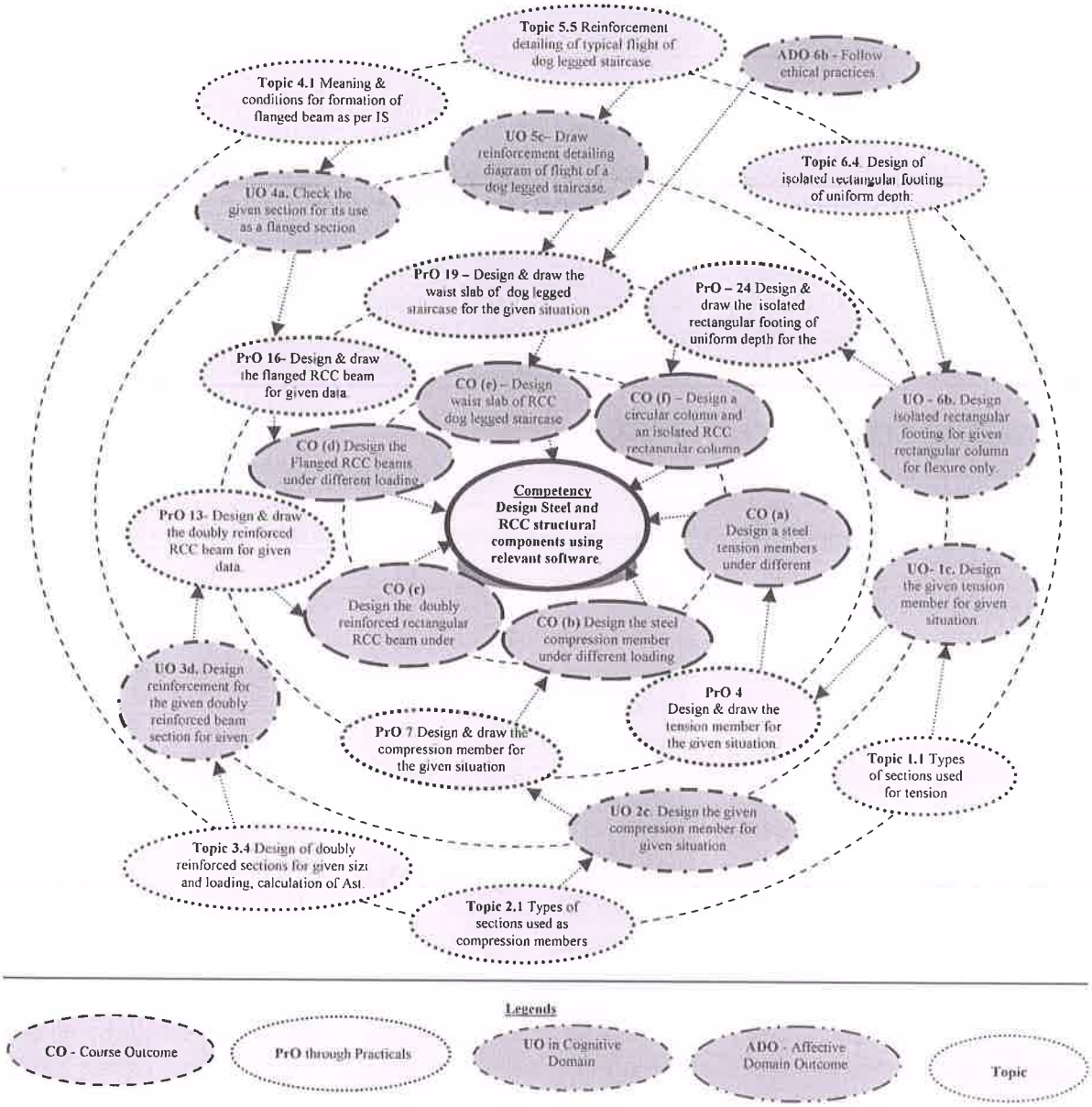

Figure 1 - Course Map

6. SUGGESTED PRACTICALS/ EXERCISES

The practicals in this section are PrOs (i.e. sub-components of the COs) to be developed and assessed in the student for the attainment of the competency.

S. No.	Practical Outcomes (PrOs)	Unit No.	Approx. Hrs. Required
1	Draw labeled sketches of five given rolled steel sections and built up sections..	I	2
2	Write the provisions of IS 800-2007 required for the design of the given tension member.	I	2
3	Determine the load carrying capacity of the given tension member for the given situation.	I	2

S. No.	Practical Outcomes (PrOs)	Unit No.	Approx. Hrs. Required
4	Design and draw a tension member for the given situation.	I	2*
5	Compile relevant clauses from IS 800-2007 required for the design of a compression member and submit it in report form.	II	2
6	Determine the effective length of the given compression member for various configurations under different end conditions with neat sketches using the relevant software.	II	2
7	Design and draw a compression member for the given situation using the relevant software.	II	2*
8	Determine the load carrying capacity of compression member for the given situation using the relevant software..	II	2
9	Draw sketches for single & double lacing of given built up columns.	II	2
10	Draw sketches for battening of given built up columns.	II	2
11	Write the provisions of IS800-2007 pertaining to design of lacing and battening along with its significance by viewing the relevant video/simulation	II	2
12	Draw cross section, strain diagram and stress diagram for doubly reinforced section by viewing the relevant software.	III	2
13	Design and draw a doubly reinforced RCC beam for given data using relevant software.	III	2*
14	Draw reinforcement details of the doubly reinforced RCC beam designed in PrO No. 13.	III	2#
15	Draw stress diagrams for Flanged sections for all cases of Neutral axis.	IV	2
16	Design and draw a flanged RCC beam for given data using relevant software..	IV	2*
17	Draw reinforcement details of the flanged RCC beam designed in PrO No 16.	IV	2#
18	Draw the neat sketches of the different staircases used in your institute building mentioning its type, tread, rise, thickness of waist slab.	V	2
19	Design and draw the waist slab of dog legged staircase for the given data using relevant software.	V	2*
20	Draw reinforcement details of waist slab for typical flight of a dog legged staircase designed in PrO No 19.	V	2*#
21	Design and draw a circular column with spiral ties for the given situation using relevant software.	VI	2
22	Draw sketches of different types of column footings.	VI	2
23	Write procedural steps for design of a rectangular RCC footing from the given data as per the relevant IS code.	VI	2
24	Design and draw the isolated rectangular footing of uniform depth for the given situation using relevant software.	VI	2*
25	Draw reinforcement details of the isolated rectangular footing designed in PrO No 24.	VI	2#
26	Interpret the given RCC Structural Drawings with reference to reinforcement details of various structural elements.	III to VI	2*
27	Prepare a checklist for reinforcement provided from the given drawings for various structural elements.	III to VI	2

S. No.	Practical Outcomes (PrOs)	Unit No.	Approx. Hrs. Required
28	Show the reinforcement detailing of structural elements like beams, columns, staircase and footing of the given structure.	III to VI	2*
29	Draw the sketches of given rolled steel tension & compression members provided in the given structures.	I and II	2
	Total		**58**

Note

i. *A suggestive list of **PrOs** is given in the above table. More such PrOs can be added to attain the COs and competency. A judicial mix of minimum 12 or more practical LOs/tutorials need to be performed, out of which, the practicals marked as '*' are compulsory, and marked as "#" indicates use of auto CAD software for drawing so that the student reaches the 'Precision Level' of Dave's 'Psychomotor Domain Taxonomy' as generally required by the industry.*

ii. *The 'Process' and 'Product' related skills associated with each PrO is to be assessed according to a suggested sample given below:*

S. No.	Performance Indicators	Weightage in %
1	Interpretation of given data and its presentation.	10
2	Selection of sketches /Process of designing of the given structural components using relevant I.S. Codes /writing of visit report.	30
3	Precision in sketch book, sheets and report and its neatness, cleanliness.	30
4	Individual work and working in groups	20
5	Submission of assigned work in time	10
	Total	**100**

The above PrOs also comprise of the following social skills/attitudes which are Affective Domain Outcomes (ADOs) that are best developed through the laboratory/field based experiences:

a) Follow safety practices.
b) Practice good housekeeping.
c) Work as a leader/a team member.
d) Follow ethical Practices.

The ADOs are not specific to any one PrO, but are embedded in many PrOs. Hence, the acquisition of the ADOs takes place gradually in the student when s/he undertakes a series of practical experiences over a period of time. Moreover, the level of achievement of the ADOs according to Krathwohl's 'Affective Domain Taxonomy' should gradually increase as planned below:

- 'Valuing Level' in 1st year.
- 'Organization Level' in 2nd year.
- 'Characterization Level' in 3rd year.

7. MAJOR EQUIPMENT/ INSTRUMENTS REQUIRED

The major equipment with broad specification mentioned here will usher in uniformity in conduct of experiments, as well as aid to procure equipment by administrators.

S. No.	Equipment Name with Broad Specifications	PrO. S. No.
1	Computers	14, 17, 20 and 25.
2	Printers	14, 17, 20 and 25.
3	Available CAD software	14, 17, 20 and 25.

8. UNDERPINNING THEORY COMPONENTS

The following topics/subtopics should be taught and assessed in order to develop UOs in cognitive domain for achieving the COs to attain the identified competency. More UOs could be added.

Unit	Unit Outcomes (UOs) (in cognitive domain)	Topics and Sub-topics
Unit – I Design of Steel Tension Members (Limit State Method).	1a. Suggest the type of the steel sections from the given data that can be used as tension member in the given structure with justification. 1b. Explain the method of computing the capacity of the given tension member for given end connection. 1c. Design the given tension member for the given situation from the specified data.	1.1 Types of sections used for Tension members. 1.2 Strength of tension member governed by yielding of section, rupture of net cross-section and block shear. 1.3 Design of axially loaded single angle and double angle tension members with bolted and welded connections.
Unit– II Design of Steel Compression Members (Limit State Method).	2a Suggest the type of the given steel sections that can be used as a compression member with justification. 2b Explain the method of computing the capacity of the given compression member for given end conditions. 2c Design the given compression member for the specified situation from the given data. 2d Explain with sketches the single and double lacing system for the given built up columns of the specified structure. 2e Explain with sketch the battening system for the given built up columns of the given structure.	2.1 Types of sections used as compression member. Calculation of effective length, radius of gyration and slenderness ratio. Permissible values of slenderness ratio as per IS 800. Design compressive stress. 2.2 Strength of axially loaded single and double angle struts connected by bolted and welded connections with gusset plate only. Limits of width to thickness ratios to prevent local buckling. 2.3 Design of axially loaded single angle and double angle compression members with bolted and welded connections. 2.4 Introduction to built up sections, lacing and battening (Meaning and purpose). Diagrams of single and double lacing and battening system. (No numerical problems)
Unit III- Analysis and Design of Doubly Reinforced Rectangular Concrete Sections by	3a Check the given section for its use as doubly or singly reinforced section from the given data. 3b Calculate the Young's modulus for the given parameters of the specified doubly reinforced beam. 3c Describe the method of determining ultimate moment of resistance of	3.1 Meaning and conditions for providing doubly reinforced sections. 3.2 Stress in steel (f_{sc}) for different values of d'/d ratio. 3.3 Analysis of doubly reinforced sections, strain and stress diagrams, numerical problems on ultimate

Unit	Unit Outcomes (UOs) (in cognitive domain)	Topics and Sub-topics
Limit State Method.	doubly reinforced beam from the given data. 3d Design reinforcement for the given doubly reinforced beam section for the specified conditions.	moment of resistance of a doubly reinforced beam. 3.4 Design of doubly reinforced sections for given size and loading, calculation of A_{st} and A_{sc} only.
Unit –IV Analysis and Design of Flanged Concrete Beams by Limit State Method	4a. Determine the reinforcement for the specified section for its use as a flanged section from the given data. 4b. Explain the procedure of calculating the effective flange width of the specified flanged beam under given situation. 4c. Explain the method of computing ultimate moment of resistance of the given flanged section. 4d. Calculate A_{st} required for the specified flanged beam for case of neutral axis lying in the flange from the given data.	4.1 Meaning and conditions for formation of flanged (T and L) beams as per IS 456:2000, comparison with rectangular beams, effective width of flange. 4.2 Analysis of singly reinforced flanged beams having neutral axis in flange or web. Determination of Moment of Resistance. 4.3 Determination of reinforcement in a singly reinforced flanged beam for the given dimensions. (Neutral axis lies in flange only).
Unit –V Design of RCC Staircase Slab by Limit State Method.	5a. Explain the procedure to calculate different loads on the waist slab of the given dog legged staircase from the given data. 5b. Design the waist slab of the given dog legged staircase from the given data. 5c. Draw reinforcement detailing diagram for the flight from the given data of the given dog legged staircase. 5d. Describe the method of determining the live load for the given type of the building.	5.1 Various clauses in IS456-2000 regarding effective span and load calculation for typical flight of a dog legged staircase. 5.2 Live load on staircase of different types of buildings such as residential, office, commercial, public, factory etc. 5.3 Load calculation for a typical flight of a dog legged staircase with load distribution on landing slab as per IS 456-2000. 5.4 Design of waist slab of a dog legged staircase for given rise, tread, width, and number of steps, with supporting beams at the ends of flight, parallel to steps. 5.5 Reinforcement detailing of typical flight of dog legged staircase.
Unit –VI Design of RCC Circular Column and Rectangular Footing by Limit State Method	6a. Design the given axially loaded short circular column with spiral ties for the given data. 6b. Design the given isolated rectangular footing for given rectangular column for flexure from the given data. 6c. Draw the reinforcement detailing for the specified type of footing from the given data. 6d. Describe the method of determining the load on the given axially loaded short column of the specified structure.	6.1 Introduction to rectangular and circular columns and related codal provisions in IS 456-2000. 6.2 Procedure and numerical problems on design of axially loaded short circular columns with lateral and spiral ties. 6.3 Procedure and numerical problems on design of axially loaded short rectangular and circular columns with lateral and spiral ties 6.4 Introduction to various types of RCC footings like isolated, stepped and sloped footings,

Unit	Unit Outcomes (UOs) (in cognitive domain)	Topics and Sub-topics
		combined footings, piles, raft, eccentric footing. 6.5 Design of isolated rectangular footing of uniform depth. Flexural design with checks for one-way shear, two-way shear and bond.

***Note**: To attain the COs and competency, above listed UOs need to be undertaken to achieve the 'Application Level' of Bloom's 'Cognitive Domain Taxonomy'.*

9. SUGGESTED SPECIFICATION TABLE FOR QUESTION PAPER DESIGN

Unit No.	Unit Title	Teaching Hours	Distribution of Theory Marks			
			R Level	U Level	A Level	Total Marks
I	Design of Steel Tension Members (by Limit State Method)	08	2	4	6	12
II	Design of Steel Compression Members (by Limit State Method)	10	2	6	6	14
III	Analysis and Design of Doubly Reinforced Rectangular Concrete Sections by Limit State Method.	08	0	6	6	12
IV	Analysis and Design of Flanged Concrete Beams by Limit State Method.	08	2	4	6	12
V	Design of RCC Staircase Slab by Limit State Method.	06	0	2	6	08
VI	Design of RCC Circular Column and Rectangular Footing by Limit State Method	08	2	4	6	12
Total		**48**	**8**	**26**	**36**	**70**

***Legends:** R=Remember, U=Understand, A=Apply and above (Bloom's Revised taxonomy)*
***Note**: This specification table provides general guidelines to assist student for their learning and to teachers to teach and assess students with respect to attainment of UOs. The actual distribution of marks at different taxonomy levels (of R, U and A) in the question paper may vary from above table.*

10. SUGGESTED STUDENT ACTIVITIES

Other than the classroom and laboratory learning, following are the suggested student-related ***co-curricular*** activities which can be undertaken to accelerate the attainment of the various outcomes in this course: Students should conduct following activities in group and prepare reports of about 5 pages for each activity, also collect/record physical evidences for their (student's) portfolio which will be useful for their placement interviews:

a) Prepare journals based on practical performed in laboratory.
b) Give seminar on relevant topic.
c) Undertake micro-projects.

11. SUGGESTED SPECIAL INSTRUCTIONAL STRATEGIES (if any)

These are sample strategies, which the teacher can use to accelerate the attainment of the various learning outcomes in this course:

a) Massive open online courses (***MOOCs***) may be used to teach various topics/sub topics.
b) ***'L' in item No. 4*** does not mean only the traditional lecture method, but different types of teaching methods and media that are to be employed to develop the outcomes.
c) About ***15-20% of the topics/sub-topics*** which is relatively simpler or descriptive in nature is to be given to the students for ***self-directed learning*** and assess the development of the COs through classroom presentations (see implementation guideline for details).
d) With respect to item No.10, teachers need to ensure to create opportunities and provisions for ***co-curricular activities***.
e) Guide student(s) in undertaking micro-projects.
f) Demonstrate students thoroughly before they start doing the practice.
g) Encourage students to refer different websites to have deeper understanding of the subject.
h) Observe continuously and monitor the performance of students in Lab.
i) Demonstrate students thoroughly before they start doing the practice.
j) Encourage students to refer different websites to have deeper understanding of the subject.

12. SUGGESTED MICRO-PROJECTS

Only one micro-project is planned to be undertaken by a student that needs to be assigned to him/her in the beginning of the semester. In the first four semesters, the micro-project are group-based. However, in the fifth and sixth semesters, it should be preferably be ***individually*** undertaken to build up the skill and confidence in every student to become problem solver so that s/he contributes to the projects of the industry. In special situations where groups have to be formed for micro-projects, the number of students in the group should ***not exceed three.***

The micro-project could be industry application based, internet-based, workshop-based, laboratory-based or field-based. Each micro-project should encompass two or more COs which are in fact, an integration of PrOs, UOs and ADOs. Each student will have to maintain dated work diary consisting of individual contribution in the project work and give a seminar presentation of it before submission. The total duration of the micro-project should not be less than ***16 (sixteen) student engagement hours*** during the course. The student ought to submit micro-project by the end of the semester to develop the industry oriented COs.

A suggestive list of micro-projects is given here. Similar micro-projects could be added by the concerned faculty:

a) Collect the information of various types steel sections used in actual practice.
b) Prepare a report on any structural software used for analysis/design of steel structure.
c) Prepare a report on any structural software used for analysis/design of RCC structure.
d) Prepare an excel program for analysis of steel tension member.
e) Prepare an excel program for analysis of steel compression member.
f) Prepare a chart showing capacity of various angle struts for different slenderness ratio.
g) Procure actual working drawing / blue print of structural design and write report after checking actual reinforcement placed at site.
h) Prepare an excel program for analysis of doubly reinforced RCC beam.
i) Prepare an excel program for analysis of flanged RCC beam.
j) Prepare a video report/ recording of actual placement of reinforcement on site.
k) Collect data from IS 456-2000 regarding effective span and load calculation for typical flight of a dog legged staircase.

13. SUGGESTED LEARNING RESOURCES :

S. No.	Title of Book	Author	Publication
1	Design of Steel Structures	Dayarathnam, P.	S. Chand and Company, Delhi, 2012 ISBN-13: 978-8121923200
2	Design of Steel Structures	Sairam, K.S.	Pearson Publication, Delhi,2015 ISBN-13:9332516308
3	Fundamentals of Reinforced Concrete	Sinha N.C. Roy S.K.	S. Chand and Co., New Delhi, 2007. ISBN-13: 978-8121901277
4	Reinforced Concrete Design Principles and Practice	Krishna Raju, N.Pranesh, R.N.	New Age International, umbai,2018 ISBN-13: 9788122414608
5	Reinforced concrete Design	Pillai, S.U. Menon, Devdas	McGraw Hill Publications, New Delhi,2017; ISBN: 978-0070141100
6	Limit State Design of Reinforced Concrete	Varghese, P. C.	PHI Learning Private Limited, Delhi, 2008, ISBN: 978-8120320390

I.S. Codes:

1 IS 800-2007 Indian Standard code of practice for use of structural steel in general building construction , BIS New Delhi.
2 IS-875-1987 Part-1 to 5: Indian Standard Code for Loading Standards.
3 IS hand book No. 1 Properties of structural steel rolled section.
4 Steel tables
5 IS 456:2000 - Plain and Reinforced concrete code of Practice
6 SP16- Design Aids for reinforced concrete to IS 456
7 I.S. 875 (Part 1-5) - 1987 code of practice of design loads for Buildings and structures.
8 SP 24 - Explanatory Handbook on IS 456
9 SP34: 1987 - Handbook on concrete reinforcement and Detailing.

14. SOFTWARE/LEARNING WEBSITES

a) https://www.youtube.com/watch?v=mtRR-5fzKo8
b) https://www.youtube.com/watch?v=X8WhkG70tAc
c) https://www.youtube.com/watch?v=-JMNMlMg-CE
d) freevideolectures.com › Civil Engineering › IIT Guwahati
e) www.youtube.com/playlist?list=PLF5B83BDDBB8FCBE3
f) nptel.ac.in/noc/individual_course.php?id=noc17-ce21
g) http://freevideolectures.com/Course/2686/Design-of-Reinforced-Concrete-Structures
h) https://www.youtube.com/watch?v=hVaB0jGcyB4
i) https://www.youtube.com/watch?v=AfHmpWlcqq4
j) https://www.youtube.com/watch?v=PDJPcQq3PZE
k) https://www.youtube.com/watch?v=GgatFNtQrBo
l) https://www.youtube.com/watch?v=A9JUGWhEW5A
m) freevideolectures.com › Civil Engineering › IIT Madras
n) https://www.youtube.com/watch?v=zwtVO3-_iNQ
o) https://www.youtube.com/watch?v=wJWt0dcgafs
p) https://www.youtube.com/watch?v=csK9eNk6S1c
q) au.autodesk.com/au-online/classes-on.../class...steel/msf11860