Program Name : **Diploma in Mechanical Engineering**

Program Code : **ME**

Semester : **Fourth**

Course Title : **Mechanical Engineering Measurements**

Course Code : **22443**

1. RATIONALE

Measurement activities are given prime importance in industry. The art of measurement plays an important role in all branches of engineering. With advances in technology, measurement techniques have also taken rapid strides, with many types of instrumentation devices, innovations, refinements. The course aims at making a Mechanical Engineering diploma holder familiar with the principles of instrumentation, transducers and measurement of non electrical parameters like temperature, pressure, flow, speed, force, torque for engineering applications.

2. COMPETENCY

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

- **Use relevant analog and digital measuring devices in mechanical engineering related applications.**

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. Use relevant instrument for measuring displacement
b. Use relevant instrument for measuring force and torque.
c. Use relevant pressure and temperature measuring instruments.
d. Use relevant instruments for measurement of flow.
e. Select relevant instruments for measurement of vibration and strain
f. Select relevant instruments for speed and sound measurement

4. TEACHING AND EXAMINATION SCHEME

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

(*): Under the theory PA, Out of 30 marks, 10 marks 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 cognitive domain 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, @* Internal Assessment, # External Assessment, *** On Line Examination, ^ Computer Based 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.

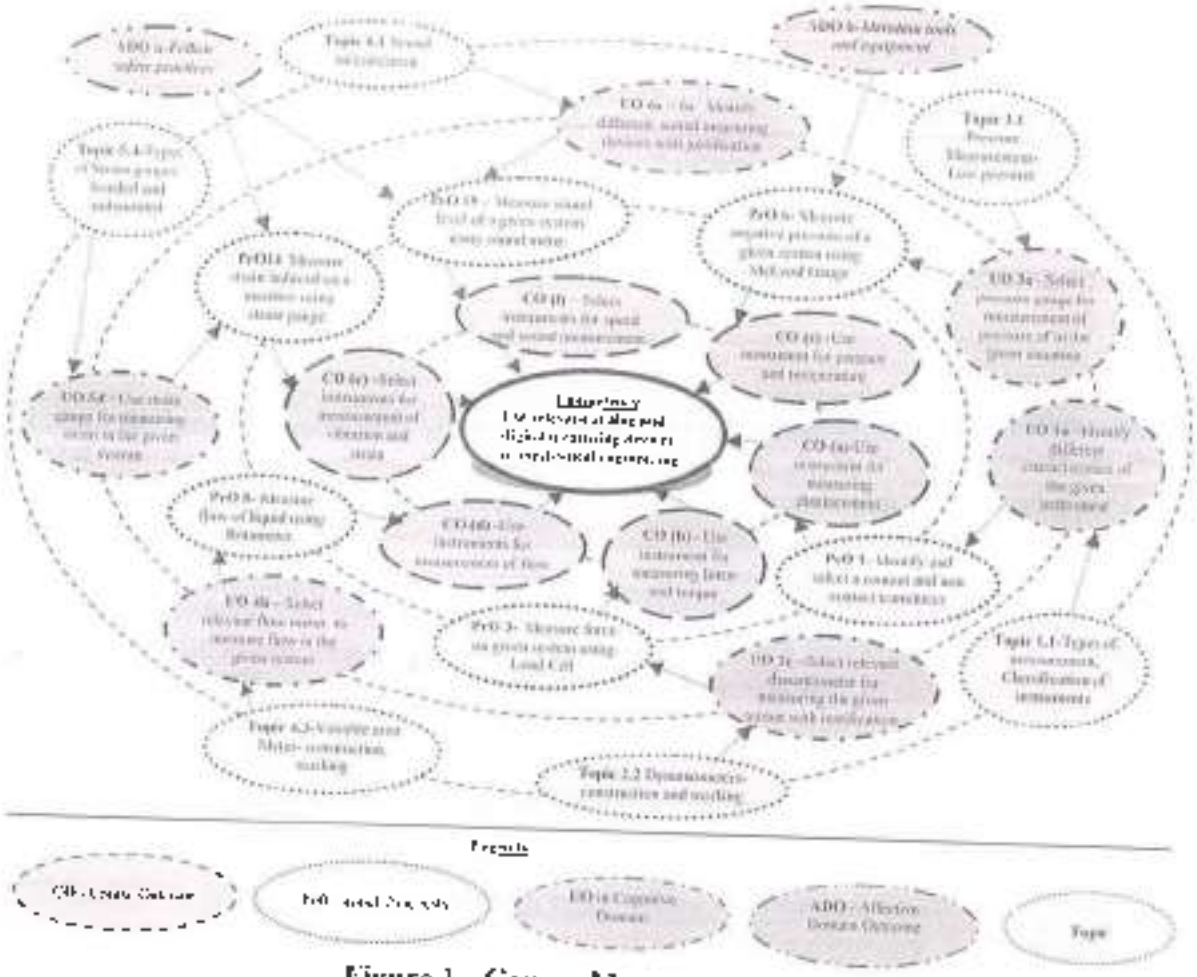

Figure 1 - Course Map

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	Identify contact and Non-Contact Type Instruments	I	02*
2	Calibration of LVDT transducer for displacement Measurement	II	02
3	Use Load cell to measure force on given system.	II	02*
4	Measure Force Using Eddy Current Dynamometer.	II	02
5	Calibration of Bourdon's Pressure gauge	III	02*
6	Measure Pressure using McLeod Gauge	III	02
7	Calibration of Thermocouple	III	02*

S. No.	Practical Outcomes (PrOs)	Unit No.	Approx. Hrs. Required
8	Measure flow of liquid by Rotameter	IV	02
9	Measure flow of liquid by Ultrasonic Flow meter	IV	02
10	Calibration of Stroboscope.	V	02*
11	Measure Speed of Rotating Machine using Inductive Pick up	V	02
12	Use of Vibration Meter for Measuring Vibration of Machine	V	02*
13	Use of Vibration Meter for Measuring Vibration of Structure	V	02
14	Use Strain gauge To measure Strain induced on member	V	02*
15	Use Psychrometer to measure Air properties	VI	02
16	Use Sound Meter to measure sound level of a given system	VI	02*
	Total		**32**

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 need to be performed out of which, the practicals marked as '' are compulsory, 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	Preparation of experimental set up	10
2	Handling of measuring instruments carefully while performing the practical.	10
2	Setting and operation	30
3	Safety measures	10
4	Observations and recording	10
5	Interpretation of result and conclusion	10
6	Answer to sample questions	10
7	Submission of report 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. Practice energy conservation.
d. Demonstrate working as a leader/a team member.
e. Maintain tools and equipment.
f. 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
- 'Organising Level' in 2nd year
- 'Characterising 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 authorities concerned.

S. No.	Equipment Name with Broad Specifications	Prac. No.
1	Inductive transducer- measurement range -0 to 100 mm -Sensor -inductive (non linear) solenoid type on board with micrometer, micrometer screw guage assembly for displacement, bridge balance type circuit Display 3.5 digit digital display	1
2	Load cell – force measurement range 5- 50 N -sensor-4 arm bridge with strain guage capacity-2 kg, 3.5 digital display	2
3	Eddy Current Dynamometer Power rating: 0.18 KW to 55 KW Max Speed: 4,000 RPM; Torque Indicator: Spring Balance OR Digital Indicator with Zero, Span, Calibration presets; Max Torque: 100 KgM (1000 Nm); Speed Sensor: 60-Tooth wheel with Magnetic Speed Pick up Sensor Torque Sensor: Spring Balance with Pulley and rope, Load cell or Rotary Torque Sensor; Cooling: Self Cooled or FAN Cooled, to avoid Water Cooling hassles	3
4	Sensor - Bourdon tube C type with LVDT Display 3.5 digit display for pressure/ displacement	4
5	Mechcol guage with arrangement for high pump	4
6	Sensor- type k (Cr- Al)thermocouple, sensor assembly and water bath with heating arrangement Display) 5digit digital display	5
7	Rotameter trainer - Sensor -standard glass rotameter, process tank with motor pump Display- float position on graduated scale	6
8	Ultrasonic flow meter: 100 PPM OF 100 Microns in Size Particulate or Bubbles Required.Battery Operated,Non-Invasive Clamp-On Transducer,Large Character Display; User Selected Velocity Units ,Measures Fluid Velocities from (0.10 to 9.00 MPS).100:1 Turndown Ratio,Pipe Sizes from 6.5 mm	7
9	Stroboscope- Range upto 5000 RPM display - LED digital	8
10	Inductive pickup for speed measurement- Sensor inductive , variable speed motor arrangement, 3.5 digital display	9
11	FFT analyzer: Specifications:Vibration Velocity: 0.1 – 200 mm/s True RMS,Acceleration: 0.1 – 200m/s² Peak,Displacement: 0.5 – 2000 µm Peak – Peak,Resolution: 0.1 mm/s,Accuracy: ± 2% + 0.1 mm/s,Frequency response: 10 – 1k hz,Power: Rechargeable battery Pack with charger,Display: 2 x 16 line back light dot matrix LCD,Operating Temp. Range: 0 – 55°C,Casing: ABS,Sealed Membrane key pad,Input Connectors: BNC Round,Size:200x100x40 mm	10
12	Strain gauge trainer (strain force measurement)- Sensor-four arm bridge with strain gauge mounted on cantilever 2kg, Display 3.5digit digital display	11

S. No.	Equipment Name with Broad Specifications	Prac. No.
13	Sling Psychrometer: The Sling Psychrometer measures RH between 10 and 100% for dry bulb temperatures between 30 and 100 °F) with an accuracy of 1.5%. Measurement Range :Dry/wet bulb temperature -25 to 120 °F or -5 to +50 °C (see ordering information). Relative humidity (RH) : 10 to 100%. for dry bulb temperature between 30 and 100 °F(1 and 38 °C)	12
14	Sound meter: LCD backlight for clear reading. Wide measuring range: 30-130dB Sound level measurement. in:Max/Peak current value. Hold the measurement data. Mercal/beta shutoff. Equipped with sponge ball. Portable and easy to use suitable for sound quality control in factory, office, home, school and construction site.	13
15	Multi digital stroboscope cum tachometer for speed measurement upto 5000 rpm	14

8. UNDERPINNING THEORY COMPONENTS

The following topics are to be taught and assessed in order to develop the sample UOs given below 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 Introduction to Measurement	1a. Identify different characteristics of the given instrument. 1b. Identify the error in the given instrument. 1c. Classify the transducers for the given application 1d. Identify the given contact and non-contact transducer with justification.	1.1 Types of measurement, Classification of instruments. Static terms and characteristics- Range and Span, Accuracy and Precision, Reliability, Calibration, Hysteresis and Dead zone, Drift, Sensitivity, Threshold and Resolution, Repeatability and Reproducibility, Linearity, Dynamic characteristics Speed of response, Fidelity and Dynamic errors, Overshoot. 1.2 Measurement of error- Classification of errors, environmental errors, signal transmission errors, observation errors, operational errors. 1.3 Classification of transducers, active and passive, contact non contact,mechanical electrical, analog digital.
Unit-II Displacement, Force and Torque Measurement	2a Select the displacement measuring sensor for measurement of displacement in the given system with justification. 2b. Select the force measuring sensors for measurement of pressure in the given situation with justification.	2.1 Specification, selection and application of displacement transducer. Capacitive transducer. Potentiometer. LVDT. RVDT. 2.2 Force Measurement, System-characteristic of force measurement. creep curve for force transducer. 2.3 Force and Load Sensors- Types of Load cell, load cell applications.

Unit	Unit Outcomes (UOs) (in cognitive domain)	Topics and Sub-topics
	2e. Select the relevant dynamometer for measuring the given torque with justification. 2f. Describe with sketches the procedure for measurement of displacement, force and torque using the given device.	construction and working of Quartz force sensor, Force rings 2.4 Torque Measurement- Inline and Reaction Torque measurement 2.5 Torque sensors- construction and working of Slip ring, Rotary Transformer, Infrared sensor, FM Transmitter 2.6 Dynamometers – construction and working of Transmission dynamometer, Absorption dynamometer, Eddy current Dynamometer
Unit – III Pressure and Temperature Measurement	3a. Select the pressure gauge for measurement of pressure in the given situation with justification. 3b. Choose the relevant instruments to measure temperature of the given system with justification. 3c. Select the relevant pyrometer for given application with justification 3d. Describe with sketches the procedure for measurement of temperature and pressure using the given device.	3.1 Pressure Measurement- Low pressure gauges- McLeod Gauge, Thermal conductivity gauge, Ionization gauge, Thermocouple vacuum gauge, Pirani gauge, High Pressure gauge- Diaphragm, Bellows, Bourdon tube, Electrical resistance type, Photoelectric pressure Transducers, piezoelectric type 3.2 Non-electrical methods- Bimetal, Liquid in glass thermometer and Pressure thermometer. 3.3 Electrical methods- RTD, Platinum resistance thermometer, Thermistor, Thermoelectric methods - elements of thermocouple, Seebeck series, law of intermediate temperature, law of intermediate metals, thermo emf Measurement. 3.4 Pyrometers- Working and Principle of Radiation and Optical Pyrometer.
Unit– IV Flow Measurement	4a. Identify the flow meter for the given situation with justification mentioning salient features. 4b. Select relevant flow meter to measure flow in the given system with justification. 4c. Describe with sketches the procedure for measurement of flow using the given Ultrasonic flow meter	4.1 Types of flow meter, Selection criteria for flow meter, classification 4.2 Flow meters - application and construction of Orifice, venturi tube, segmental wedges, pitot tube, Dall Tube. 4.3 Variable area Meter- construction, working and principle of Rota meter, anemometer. 4.4 Positive Displacement Flow meter- construction, advantages and disadvantages of Coriolis flow meter, Oscillating piston flow meter

Unit	Unit Outcomes (UOs) (in cognitive domain)	Topics and Sub-topics
		Rotating vane flow meter. 4.5 Ultrasonic flow meter- application and construction of Doppler and Transit time ultrasonic flow meter.
Unit –V Vibration and Strain Measurement	5a. Select the relevant instrument for vibration measurement of given job with justification. 5b. Describe with sketches the use of FFT analyzer for measuring vibration of the given system. 5c. Identify the relevant strain gauges for measuring strain in the given system with justification. 4d. Describe with sketches the procedure for measurement of strain in the given system using strain gauge.	5.1 Concept of natural frequency, free body diagram and spring mass system. 5.2 Vibration measurement element principle and working of velocity pickup ,Accelerometer Inductive Pick Up, Capacitive Pick Up , Stroboscope. 5.3 Introduction to FFT Analyzer, working and application. 5.4 Types of Strain gauges- bonded and unbonded, gauge factor, strain gauge selection criteria. 5.5 Methods of strain measurement- Axial, bending, Torsional. 5.6 Construction of foil, semiconductor and wire wound strain gauge.
Unit–VI Miscellaneous Measurement Sound, speed and humidity measurements	6a. Identify the relevant sound measuring device for the given situation with justification and mentioning the salient features. 6b. Describe with sketches the use speed measuring instrument for the given system. 6c. Select the relevant instrument for measuring Humidity in the given system with justification. 6d. Describe with sketches the procedure for measurement of Humidity using the given device.	6.1 Sound measurement, principle of Electro dynamic microphone and Carbon microphone. 6.2 Speed measurement working and principle of Eddy current generation type tachometer, incremental and absolute type, Mechanical Tachometers, Revolution counter and timer, Slipping Clutch Tachometer. Electrical Tachometers, Contact less Electrical tachometer. 6.3 Humidity measurement - working and principle of Hair hygrometer, Sling psychrometer.

Note: To attain the COs and competency, above listed UOs need to be undertaken to achieve the 'Application Level' and above 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	Introduction to Measurement	06	02	04	06	12
II	Force and Torque Measurement	10	02	04	06	12
III	Pressure and Temperature Measurement	08	02	04	06	12
IV	Flow Measurement	08	02	04	06	12
V	Vibration and Strain Measurement	08	02	04	04	10
VI	Miscellaneous Measurement	08	02	02	08	12
Total		**48**	**12**	**22**	**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 journal based on practical performed in measurement laboratory. Journal consist of drawing, observations , required measuring tools, equipments, date of performance with teacher signature.

b. Prepare/Download a specifications of followings.
   i Measuring Tools and equipment in measurement laboratory.
   ii Machineries in measurement laboratory

c. Undertake a market survey of local dealers for measuring equipments and prepare a report.

d. Visit to any Tool room and observe the working of inspection and testing department. also prepare a report consisting
   i. Different advanced Measuring Instruments
   ii. Different Measuring standards and Calibration process
   iii. Care and maintenance of measuring instruments observed

11. SUGGESTED SPECIAL INSTRUCTIONAL STRATEGIES

These are sample strategies, which the teacher can use to accelerate the attainment of the various 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 UOs 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. Before starting practical, teacher should demonstrate the working of instrument.
g. Instructions to students regarding care and maintenance of measuring equipments.
h. Show video/animation films to explain functioning of various measuring Instruments.
i. Teacher should ask the students to go through instruction and Technical manuals of instruments.

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 are given here. Similar micro-projects could be added by the concerned faculty:

a. Predict and test the performance of sensors of various kinds, including strain gages, thermocouples, tachometers, displacement transducers, dynamometers, pressure gages and transducers.
b. Collect information of flow measuring devices.
c. Perform comparative study of different parameters of LVDT various contact sensors.
d. Perform comparative study of various non - contact sensors.
e. Visit to automobile workshop and observe the various sensors used in car also prepare report of the same i.e name ,use, location, function.
a. Visit the market and collect the sensor brochures with specifications of different manufactures.
b. Prepare a list of instruments used for vibration measurement and analysis.
c. Visit a power plant or manufacturing industry and identify situations where these sensors and instruments are used for predictive maintenance and condition monitoring.

13. SUGGESTED LEARNING RESOURCES

S. No.	Title of Book	Author	Publication
1	Mechanical measurements and instrumentation	Rajput R.K.	S.K.Kataria and Sons, New Delhi, 2013, ISBN:978-93-5014-285-1
2	Mechanical Measurement and Control	Jalgaonkar R.V.	Everest Publishing House, New Delhi, 2010, ISBN-9788186314265
3	Mechanical and Industrial Measurements	Jain R.K.	Khanna Publications, New Delhi, 2012, ISBN: 978-8174091912

S. No.	Title of Book	Author	Publication
4	Instrumentation Devices and Systems	Narang C.S.	Tata McGraw Hill Publications, New Delhi, 2012, ISBN: 978-0074633502
5	Instrumentation, Measurement and Analysis	Nakra B. C.; Chaudhary K.K.	Tata McGraw Hill Publications, 2010, New Delhi, ISBN:0070482969

14. SUGGESTED SOFTWARE/LEARNING WEBSITES

a. http://nptel.ac.in/courses/112106138
b. https://cosmolearning.org/video-lectures/pyrometry-cem
c. https://www.youtube.com/watch?v=Vpm7dsY4C4
d. www.youtube.com/watch?v=qNIIZYAk9pI
e. https://www.youtube.com/watch?v=xrvNHIHY9o
f. https://www.youtube.com/watch?v=DxdHIDrFBc
g. https://www.youtube.com/watch?v=-ZeHgVjqje
h. https://www.youtube.com/watch?v=iTjl5PHIADA4
i. https://www.youtube.com/watch?v=I4b644S_64w
j. https://www.youtube.com/watch?v=XQTGRSNN9oA
k. https://www.youtube.com/watch?v=FgNAIKTTNtE
l. https://www.youtube.com/watch?v=sL/eR7RMuFA
m. https://www.youtube.com/watch?v=QGBRwXoxnU
n. https://www.youtube.com/watch?v=jTFRMVlgbmNU
o. https://www.youtube.com/watch?v=KeZ5CP9IBe
p. https://www.youtube.com/watch?v=3hOVIbGSQ0c
q. https://www.youtube.com/watch?v=8HsNyYPTXPA
r. https://www.youtube.com/watch?v=FWqIhh9ZLjk
s. https://www.youtube.com/watch?v=j-u3IIgeHiQ
t. https://www.youtube.com/watch?v=CLEP5IQ-y0I