UNIT 430 ENGINEERING FLUID MECHANICS AND THERMODYNAMICS

Lesson 1: Introduction and basic principles **Suggested Teaching Time:** 2 hours

Learning Outcome: Understand the principles of fluid mechanics

Topic	Suggested Teaching	Suggested Resources
Introduction and basic principles	• The tutor should go through the unit specification and explain the need for an understanding of the principles of fluid mechanics and thermodynamics as they apply in mechanical engineering. A short question and answer session should be used to check learner understanding of what is to be covered, but it is clearly not a requirement for learners to understand the content before it is taught. • The learners should be provided with a glossary of the terms to be used in the unit and encouraged to align each term against specific assessment criteria, as and where relevant. Each term will of course be fully explained later, at the appropriate stage of the teaching and learning process. • The tutor should use the unit specification to explain how the unit is to be assessed. This should deal with whether the assessment is to be external or internal, by examination or assignment, and the nature of the evidence that will need to be provided.	• Unit specification • Glossary of terms • Sample assessment materials **Websites:** www.imeche.org (Institution of Mechanical Engineers) www.engc.org.uk (Engineering Council) www.instituteofwater.org.uk (Institute of Water)

Lesson 2: Hydrostatic forces in stationary fluids **Suggested Teaching Time:** 4 hours

Learning Outcome: Understand the principles of fluid mechanics

Topic	Suggested Teaching	Suggested Resources
Hydrostatic forces in stationary fluids (AC 1.1)	• The tutor should differentiate between hydrostatics and hydrodynamics and introduce the basic assumptions that underpin hydrostatics (fluids considered incompressible, pressure acts with equal magnitude in all directions, fluids exert pressure normal to any containing surface). • Learners should undertake independent research into Pascal's law and the formula used to determine pressure at depth. • A discussion should be used to link pressure in a fluid of constant density and 'pressure head' in metres. • Learners should measure fluid pressure and pressure differentials using manometers, Bourdon gauges and piezometers. The tutor should explain the underpinning principles in each case. • Worked examples should be provided of calculations of pressure at depth and forces acting on totally or partially submerged plane surfaces, both inclined and vertical. Learners should practise these calculations, and the tutor should check these and amend as and where necessary. • The tutor must define the concept of 'depth of centre of pressure' and learners should check this by experiment, using equipment designed for this purpose. The websites to the right will help.	**Books:** Massey, Bernard S., and Ward-Smith, John, *Mechanics of Fluids* 9th edition, Taylor and Francis Ltd (2011), ISBN-10: 0415602599, ISBN-13: 978-0415602594 **Websites:** (Centre of pressure) https://www.youtube.com/watch?v=Gi4qBOjVAXk http://www.tecquipment.com/Datasheets/H11_0511.pdf http://www.scribd.com/doc/48248012/Center-of-Pressure-on-a-Submerged-Plane-Surface

Lesson 3: The stability of floating bodies under different conditions

Suggested Teaching Time: 4 hours

Learning Outcome: Understand the principles of fluid mechanics

Topic	Suggested Teaching	Suggested Resources
The stability of floating bodies under different conditions (AC 1.2)	• The tutor should introduce the concepts of buoyancy and stability of floating bodies and partially immersed bodies, with special reference to Archimedes' principle and the implications for upthrust on an immersed body. The 'different conditions' should be discussed in terms of changes in the density of the fluid and changes in the shape and density of the body immersed in the fluid. • Learners should undertake independent research into the concepts of stable, unstable and neutral equilibrium and the terms metacentre, metacentric height and overturning moment. They should produce hard copies of their findings to support a whole-class discussion. • The tutor should introduce the special case of anchored buoys and define the angle of tilt and explain its relevance. • A laboratory experiment to demonstrate buoyancy and stability, and to determine relevant parameters should be undertaken. The websites shown on the right will help inform the underpinning principles and the practical work.	**Books:** Massey, Bernard S., and Ward-Smith, John, *Mechanics of Fluids* 9th edition, Taylor and Francis Ltd (2011), ISBN-10: 0415602599, ISBN-13: 978-0415602594 **Websites:** https://www.youtube.com/watch?v=QUgXf2Rj2YQ http://user.engineering.uiowa.edu/~me_160/lecture_notes/lec04_2012.pdf http://www-mdp.eng.cam.ac.uk/web/library/enginfo/aerothermal_dvd_only/aero/fprops/statics/node23.html http://user.engineering.uiowa.edu/~me_160/lecture_notes/lec04_2012.pdf

UNIT 430 ENGINEERING FLUID MECHANICS AND THERMODYNAMICS

Lesson 4: The effect of viscosity on the steady flow of ideal fluids

Suggested Teaching Time: 4 hours

Learning Outcome: Understand the principles of fluid mechanics

Topic	Suggested Teaching	Suggested Resources
Evaluate the steady flow of an ideal fluid (AC 1.3) Evaluate the **effects** of fluid viscosity on the steady flow of a fluid (AC 1.4)	• The tutor must introduce learners to ideal fluid motion and the effects of viscosity, friction, shear forces and streamlines on different types of flow (turbulent, viscous/laminar) and the relevance of Reynolds number. • Learners should do independent research on definitions of ideal liquid flow including uniform, steady and unsteady flow, and explore how each depends on time and area. • The tutor must then relate the independent research to concepts of continuity of flow, conservation of mass, the momentum of a fluid and the rate of change of momentum of a fluid. • Practical work should be used to relate the energy of a fluid (potential energy, kinetic energy, pressure energy) to the total energy. A hydraulic bench and a Venturi meter could be used to help demonstrate Bernoulli's theorem.	**Books:** Massey, Bernard S., and Ward-Smith, John, *Mechanics of Fluids* 9th edition, Taylor and Francis Ltd (2011), ISBN-10: 0415602599, ISBN-13: 978-0415602594 **Websites:** www.youtube.com/watch?v=p08_KITKP50 (Laminar flow) www.youtube.com/watch?=mmB_o5Auf-s (Bernoulli's principle)

UNIT 430 ENGINEERING FLUID MECHANICS AND THERMODYNAMICS

Lesson 5: Thermodynamic concepts **Suggested Teaching Time:** 4 hours

Learning Outcome: Understand the use of thermodynamics laws in engineering applications

Topic	Suggested Teaching	Suggested Resources
Thermodynamic concepts (AC 2.1)	• The tutor must introduce learners to the terminology and basic concepts that underpin the study of the laws of thermodynamics and basic processes involving steady-state flow. • These must include the following: system, control volume, states, reversible and irreversible processes, cycles, temperature equilibrium, conservation of energy. • Learners should follow this up with independent research involving access to the e-books and websites indicated on the right. • The tutor should create a short formative test for the learners to undertake. If this is done on the computer, with the learner having to repeat the test until they achieve, say, 75% of the available marks, the tutor can move forward to the next lessons, with some confidence that the learners do understand the basic concepts of thermodynamics.	**Books:** Rogers, Gordon, and Mayhew, Yon, *Engineering Thermodynamics: Work and Heat Transfer*, 4th edition, Longman Scientific, 1992, ISBN-10: 0582045665, ISBN-13: 978-0582045668 Moran, Michael J., Shapiro, Howard N., Boettner, Daisie D., and Bailey, Margaret B., *Principles of Engineering Thermodynamics*, 7th edition, John Wiley and Sons, 2011, ISBN: 0470918012 **E-Book:** *Engineering Thermodynamic*s (free download), Tarik Al-Shemmeri http://tinyurl.com/ooshzet **Websites:** Basic concepts of thermodynamics (PPT) http://tinyurl.com/mjkcrh5 Thermodynamics – an engineering system (PPT) Mehmet Kanoghu http://tinyurl.com/nyw4zvd

UNIT 430 ENGINEERING FLUID MECHANICS AND THERMODYNAMICS

Lesson 6: Energy transfers in engineering systems and applications of the first law of thermodynamics

Suggested Teaching Time: 4 hours

Learning Outcome: Understand the use of thermodynamics laws in engineering applications

Topic	Suggested Teaching	Suggested Resources
Energy transfers in engineering systems (AC 2.2) Applications of first law of thermodynamics to engineering (AC 2.3)	• The tutor must explain the concepts of work transfer, work done at a moving boundary, work done in a cycle of processes and the heat transfers involved. • A whole-class discussion should follow concerning how the principle of conservation of energy implies the First Law of Thermodynamics and its applications. The tutor should lead the learners towards an understanding of how a change in the internal energy of a closed system is equal to the amount of heat supplied to the system minus the amount of work done by the system on its surroundings. The websites on the right will help. • The tutor should provide diagrams of typical thermodynamic cycles for the learners to study, particularly in terms of closed systems in non-cyclic processes, with a control volume in a steady-state steady-flow process. • Worked examples of associated calculations should be provided to supplement the thermodynamic cycle diagrams. The tutor should explain these and then provide examples for the learners to work through.	**Books:** Rogers, Gordon, and Mayhew, Yon, *Engineering Thermodynamics: Work and Heat Transfer*, 4th edition, Longman Scientific, 1992, ISBN-10: 0582045665, ISBN-13: 978-0582045668 Moran, Michael J., Shapiro, Howard N., Boettner, Daisie D., and Bailey, Margaret B., *Principles of Engineering Thermodynamics*, 7th edition, John Wiley and Sons, 2011, ISBN: 0470918012 **E-Book** *Engineering Thermodynamics* (free download) Tarik Al-Shemmeri http://tinyurl.com/ooshzet **Websites:** Basic concepts of thermodynamics (PPT) http://tinyurl.com/mjkcrh5 Thermodynamics – an engineering system (PPT) Mehmet Kanoghu http://tinyurl.com/nyw4zvd

Lesson 7: Processes involving pure substances and the Second Law of Thermodynamics **Suggested Teaching Time:** 8 hours

Learning Outcome: Understand the use of thermodynamics laws in engineering applications

Topic	Suggested Teaching	Suggested Resources
Thermodynamic properties of pure substances (AC 2.4) Thermodynamic processes involving pure substances (AC 2.5) The importance of the second law of thermodynamics in engineering process analysis (AC 2.6) Changes of entropy in reversible and irreversible thermodynamic processes (AC 2.7)	• The tutor must explain the concept of a 'pure substance' as a substance that has a fixed chemical composition throughout a thermodynamic process. • A whole-class discussion should be used to consider why, for example, a mixture of liquid water and water vapour is considered a pure substance, and a mixture of a liquid and gaseous air is not. • Learners should undertake independent research into the thermodynamic properties of pure substances. The e-resources on the right will help. • The tutor must then link the above with the Second Law of Thermodynamics and its important applications. • The learners should work in small groups to research one topic per group – reversible and irreversible thermodynamic processes, the importance of constant temperature and/or pressure, what is meant by the terms entropy, isothermal and adiabatic, and how polytropic processes obey the relation $pv^n = C$). • Each group should present charts, tables, diagrams and specimen calculations as appropriate.	**Books:** Rogers, Gordon, and Mayhew, Yon, *Engineering Thermodynamics: Work and Heat Transfer*, 4th edition, Longman Scientific, 1992, ISBN-10: 0582045665, ISBN-13: 978-0582045668 **E-Book:** *Engineering Thermodynamics* (free download), Tarik Al-Shemmeri http://tinyurl.com/ooshzet **Websites:** Thermodynamics – properties of pure substances http://tinyurl.com/ooxt4nz Basic concepts of thermodynamics (PPT) http://tinyurl.com/mjkcrh5 Thermodynamics – an engineering system (PPT) Mehmet Kanoghu http://tinyurl.com/nyw4zvd

UNIT 430 ENGINEERING FLUID MECHANICS AND THERMODYNAMICS

Lesson 8: Solution of steady-state flow processes **Suggested Teaching Time:** 5 hours

Learning Outcome: Be able to solve practical steady-state engineering problems

Topic	Suggested Teaching	Suggested Resources
Application of fluid mechanics to the solution of steady-state flow processes (AC 3.1)	• The tutor should recap what has been learned in terms of fluid mechanics and explain how this learning is now to be applied to the solution of steady-state processes. • The processes to be explained, derived or solved are fluid flow measurements in pipes and ducts, simple fluid pumping systems, oil-spill containment, flood control and the stabilisation of floating vessels. • The solutions can be derived from practical experimentation, computer modelling and calculation, as appropriate, and where resources are available. • The above should include some, but not all, of the following, depending on the time and resources available – Archimedes' principle and the centre of gravity of floating bodies; Bernoulli's law and coefficients of discharge; the Chezy, Manning and D'Arcy formulae; pumping head calculations; downdraw and backwater curves; hydraulic jump. • Normal practices are best here – the tutor must work through some examples, learners should practise the calculations and the tutor must amend these, and correct as appropriate.	**Books:** Douglas, John F., Gasiorek, Janusz M., Swaffield, John A., and Jack, Lynne B., *Fluid Mechanics*, 6th edition, Pearson 2011, 978-0-13-129293-2, ISBN-10: 0273717723, ISBN-13: 978-0273717720 **E-book:** *Engineering Fluid Mechanics Solution Manual* Prof. T. T. Al-Shemmeri http://tintyurl.com/obv8bdo

Lesson 9: Practical steady-state thermodynamic processes **Suggested Teaching Time:** 8 Hours

Learning Outcome: Be able to solve practical steady-state engineering problems

Topic	Suggested Teaching	Suggested Resources
Application of the laws of thermodynamics to practical steady state thermodynamic processes (AC 3.2)	• The tutor should recap what has been learned in terms of thermodynamics and explain how this learning is now to be applied to the solution of steady-state thermodynamic processes. • The processes to be explained, derived or solved are simple steam- and gas-power processes, heating and cooling of gases and vapours in closed vessels, and the measurement of compressible fluid flows • The solutions can be derived from practical experimentation, computer modelling and calculation, as appropriate, and where resources are available. • Normal practices are best here – the tutor must work through some examples, learners should practise the calculations and the tutor must amend these, and correct as appropriate. • Learners will be able to support their learning by research using the website shown on the right.	**Books:** Rogers, Gordon, and Mayhew, Yon, *Engineering Thermodynamics: Work and Heat Transfer*, 4th edition, Longman Scientific, 1992, ISBN-10: 0582045665, ISBN-13: 978-0582045668 **Website:** Learn Thermodyamics (LearnThermo.com) http://www.learnthermo.com/examples.php

Suitable texts to support learning

Rogers, Gordon, and Mayhew, Yon, *Engineering Thermodynamics: Work and Heat Transfer*, 4th edition, Longman Scientific, 1992, ISBN-10: 0582045665, ISBN-13: 978-0582045668

Moran, Michael J., Shapiro, Howard N., Boettner, Daisie D., and Bailey, Margaret B., *Principles of Engineering Thermodynamics*, 7th edition, John Wiley and Sons, 2011, ISBN: 0470918012

Massey, Bernard S., and Ward-Smith, John, *Mechanics of Fluids* 9th edition, Taylor and Francis Ltd (2011), ISBN-10: 0415602599, ISBN-13: 978-0415602594

Douglas, John F., Gasiorek, Janusz M., Swaffield, John A., and Jack, Lynne B., *Fluid Mechanics*, 6th edition, Pearson 2011, 978-0-13-129293-2, ISBN-10: 0273717723, ISBN-13: 978-0273717720

Helpful web links to practical demonstrations and images of appropriate experimental work.

Centre of Pressure

1. https://www.youtube.com/watch?v=Gi4qBOjVAXk
2. http://www.tecquipment.com/Datasheets/H11_0511.pdf
3. http://www.scribd.com/doc/48248012/Center-of-Pressure-on-a-Submerged-Plane-Surface

Buoyancy and Stability

1. https://www.youtube.com/watch?v=QUgXf2Rj2YQ
2. http://www-mdp.eng.cam.ac.uk/web/library/enginfo/aerothermal_dvd_only/aero/fprops/statics/node23.html
3. https://www.google.co.uk/search?q=buoyancy+and+stability&client=safari&rls=en&tbm=isch&tbo=u&source=univ&sa=X&ei=r4zjU7CvNObT7Abl7oFY&ved=0CEcQsAQ&biw=1271&bih=780
4. http://user.engineering.uiowa.edu/~me_160/lecture_notes/lec04_2012.pdf

Thermodynamics

1. http://web.mit.edu/16.unified/www/FALL/thermodynamics/notes/node11.html
2. http://web.mit.edu/16.unified/www/FALL/thermodynamics/thermo_2.htm
3. http://www.learnthermo.com/T1-tutorial/ch01/intro.php
4. First law of thermodynamics
5. http://www.engineeringtoolbox.com/law-thermodynamics-d_93.html
6. Second law of thermodynamics http://entropysite.oxy.edu/students_approach.html
7. Thermodynamics properties and processes http://www.cambridge.org/us/engineering/turns/assets/052185043 6c02_p046-171.pdf
8. Learn Thermodynamics http://www.learnthermo.com/examples.php
9. Thermodynamic cycles
10. http://ocw.mit.edu/courses/physics/8-01t-physics-i-fall-2004/lecture-notes/w13d2_class_32.pdf
11. Thermodynamic cycles http://www.phys.unsw.edu.au/PHYS2060/pdf/Thermodynamic%20Cycles.pdf
12. Pure substances in thermodynamics http://www.google.co.uk/url?sa=t&rct=j&q=&esrc=s&source=web&cd=1&ved=0CCIQFjAA&url=http%3A%2F%2Fhighered.mheducation.com%2Fsites%2Fdl%2Ffree%2F0072884959%2F240292%2FChapter03.ppt&ei=KcDjU-2fCJTo7AaZvIGgAQ&usg=AFQjCNHmlXd-Y4nehwy-ykY7_niwOORQnA&sig2=NH7chZkIBjjVUw9Ln34ydw&bvm=bv.72676100,d.ZGU