Module (Course Syllabus) Catalogue

2023-2024

College/ Institute	Erbil Technology College	
Department	Automotive Technology	
Module Name	Theory of engine design	
Module Code		
Degree	Technical Diploma ☐ Bachelor ■ High Diploma ☐ Master ☐ PhD ☐	
Semester	8th	
Qualification	PhD	
Scientific Title	Lecturer	
ECTS (Credits)		
Module type	Prerequisite ☐ Core ■ Assist. ☐	
Weekly hours		
Weekly hours (Theory)	(3)hr Class	( )Total hrs Workload
Weekly hours (Practical)	(0)hr Class	( )Total hrs Workload
Number of Weeks	12	
Lecturer (Theory)	Dr. Barhm Abdullah Mohamad	
E-Mail & Mobile NO.	barhm.mohamad@epu.edu.iq 07512209152	
Lecturer (Practical)		
E-Mail & Mobile NO.		
Websites		

Course Book

<table>
<tr><td>Course Description</td><td colspan="5">This course will emphasize the illustration of fundamental concepts in engine design, exploring its multidisciplinary nature, which encompasses subjects like thermodynamics, mechanics, materials science, and control systems, among other areas. Progress in these domains plays a pivotal role in fostering the evolution of engines that are not only more efficient and powerful but also environmentally friendly.</td></tr>
<tr><td>Course objectives</td><td colspan="5">• Providing knowledge about Understanding and manipulating the thermodynamic processes within the engine to maximize efficiency and power output.
• Analysing how Selecting and designing engine components with materials that balance strength, weight, and heat resistance.
• Educating students to solve problems.</td></tr>
<tr><td>Student's obligation</td><td colspan="5">• Attending classes and participate in the lecture.
• Make reports and studies on different topics.
• Assignment preparations.
• Make quizzes and exams to make sure they got necessary knowledges.</td></tr>
<tr><td>Required Learning Materials</td><td colspan="5">• Handouts, notes and references.
• Showing necessary videos and reports.
• Showing equipment on different sites if possible.</td></tr>
<tr><td rowspan="13">Evaluation</td><td colspan="2">Task</td><td>Weight (Marks)</td><td>Due Week</td><td>Relevant Learning Outcome</td></tr>
<tr><td colspan="2">Paper Review</td><td></td><td></td><td></td></tr>
<tr><td rowspan="5">Assignments</td><td>Homework</td><td>5</td><td></td><td></td></tr>
<tr><td>Class Activity</td><td>2</td><td></td><td></td></tr>
<tr><td>Report</td><td>10</td><td></td><td></td></tr>
<tr><td>Seminar</td><td>10</td><td></td><td></td></tr>
<tr><td>Essay</td><td></td><td></td><td></td></tr>
<tr><td>Project</td><td></td><td></td><td></td></tr>
<tr><td colspan="2">Quiz</td><td>8</td><td></td><td></td></tr>
<tr><td colspan="2">Lab.</td><td>15</td><td></td><td></td></tr>
<tr><td colspan="2">Midterm Exam</td><td>10</td><td></td><td></td></tr>
<tr><td colspan="2">Final Exam</td><td>40</td><td></td><td></td></tr>
<tr><td colspan="2">Total</td><td>100</td><td></td><td></td></tr>
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Specific learning outcome:	1- Theory of engine design. 2- Analyzing problems. 3- Solving selection and design problems.
Course References:	1. V. Ganesan, "IC Engines Fourth Edition Handbook," Tata McGraw Hill Education Private Limited, 2003. 2. S. Amroune, A. Belaadi, N. Menasri, M. Zaoui, B. Mohamad, H. Amin, "New approach for computer-aided static balancing of turbines rotors," Diagnostyka, vol. 20, no. 4, 2019, DOI: 10.29354/diag/114621. 3. Б Мохамед, Я Кароли, АА Зеленцов, Трехмерное моделирование течения газа во впускной системе автомобиля «Формулы Студент» Журнал Сибирского федерального университета, 13(5), pp. 597-610, 2020. DOI: 10.17516/1999-494X-0249. 4. B. Mohamad, J. Karoly, A. Zelentsov, "CFD modelling of formula student car intake system," Facta Universitatis, Series: Mechanical Engineering, vol. 18, no. 1, pp. 153-163, 2020, DOI: 10.22190/FUME190509032M.

Course topics (Theory)	Week	Learning Outcome
Introduction	1	General information about engines and their parameters
Engine cycles	2	Importance of types of engine cycles
Functional Requirements of an Injection System	3	The selection of heat exchanger
Quality of engine Fuels	4	Engine fuel types
The Phenomenon of Knock in CI Engines	5	Engine knocking and their causes
Direct Frictional Losses	6	Losse types and its approaches
Engine Power	7	The influence of engine power parameters
Combustion	8	The combustion processes
Engine Performance Characteristics	9	Importance of Engine Performance Characteristics

Methods of Improving Engine Performance	10	The importance of optimization technique
Heat Balance	11	The basics of thermodynamic analysis
AVL Engine design software	12	Basics of engine design software
Practical Topics	**Week**	**Learning Outcome**

Questions Example Design

4.1 An eight-cylinder, four-stroke engine of 9 cm bore and 8 cm stroke with a compression ratio of 7 is tested at 4500 rpm on a dynamometer which has 54 cm arm. During a 10 minutes test the dynamometer scale beam reading was 42 kg and the engine consumed 4.4 kg of gasoline having a calorific value of 44000 kJ/kg. Air 27 °C and 1 bar was supplied to the carburettor at the rate of 6 kg/min. Find (i) the brake power delivered (ii) the brake mean effective pressure (iii) the brake specific fuel consumption (iv) the brake specific air consumption (v) the brake thermal efficiency (vi) the volumetric efficiency and (vii) the air-fuel ratio.

$$bp = \frac{2\pi NT}{60000}$$

$$= \frac{2 \times \pi \times 4500 \times 42 \times 0.54 \times 9.81}{60000} = \mathbf{104.8\ kW} \quad \Longleftarrow \textbf{Ans}$$

$$bmep = \frac{bp \times 60000}{LAnK} = \frac{104.8 \times 60000}{0.08 \times \frac{\pi}{4} \times 0.09^2 \times \frac{4500}{2} \times 8}$$

$$= 6.87 \times 10^5\ \text{Pa} = \mathbf{6.87\ bar} \quad \Longleftarrow \textbf{Ans}$$

$$bsfc = \frac{\frac{4.4}{10} \times 60}{104.8} = \mathbf{0.252\ kg/kW\ h} \quad \Longleftarrow \textbf{Ans}$$

$$bsac = \frac{6 \times 60}{104.8} = \mathbf{3.435\ kg/kW\ h} \quad \Longleftarrow \textbf{Ans}$$

$$\eta_{bth} = \frac{bp}{\dot{m}_f \times CV} = \frac{104.9 \times 60}{\frac{4.4}{10} \times 44000} \times 100 = \mathbf{32.5}\% \quad \Longleftarrow \textbf{Ans}$$

Volume flow rate of air at intake condition

$$\dot{V}_a = \frac{\dot{m}_a RT}{p} = \frac{6 \times 287 \times 300}{1 \times 10^5} = 5.17\ \text{m}^3/\text{min}$$

$$V_s = \frac{\pi}{4} D^2 LnK = \frac{\pi}{4} \times 0.09^2 \times 0.08 \times \frac{4500}{2} \times 8 = 9.16\ \text{m}^3/\text{min}$$

$$\eta_v = \frac{5.17}{9.16} \times 100 = \mathbf{56.44}\% \quad \Longleftarrow \textbf{Ans}$$

$$imep = \frac{\frac{bp}{\eta_m} \times 60000}{LAnK} = \frac{\frac{31.39}{0.8} \times 60000}{0.12 \times \frac{\pi}{4} 0.1^2 \times \frac{1600}{2} \times 4} \quad \Longleftarrow \textbf{Ans}$$

$$= 7.8 \times 10^5\ \text{Pa} = \mathbf{7.8\ bar} \quad \Longleftarrow \textbf{Ans}$$

$$bsfc = \frac{\dot{m}_f}{bp} = \frac{0.2 \times 60}{31.39} = \mathbf{0.382\ kg/kW\ h} \quad \Longleftarrow \textbf{Ans}$$

4.2 The following details were noted in a test on a four-cylinder, four-stroke engine, diameter = 100 mm; stroke = 120 mm; speed of the engine = 1600 rpm; fuel consumption = 0.2 kg/min; calorific value of fuel is 44000 kJ/kg; difference in tension on either side of the brake pulley = 40 kg; brake circumference is 300 cm. If the mechanical efficiency is 80%, calculate (i) brake thermal efficiency (ii) indicated thermal efficiency (iii) indicated mean effective pressure and (iv) brake specific fuel consumption

Solution

$$bp = \frac{2\pi NT}{60000} = \frac{2\pi NWR}{60000} = \frac{WN2\pi R}{60000}$$

$$= \frac{40 \times 9.81 \times 1600 \times 3}{60000} = 31.39 \text{ kW}$$

$$\eta_{bth} = \frac{bp}{\dot{m}_f \times CV} \times 100 = \frac{31.39 \times 60}{0.2 \times 44000} \times 100 = \mathbf{21.40}\% \quad \Longleftarrow \textbf{Ans}$$

$$\eta_{ith} = \frac{\eta_{bth}}{\eta_m} \times 100 = \frac{0.214}{0.80} \times 100 = \mathbf{26.75}\% \quad \Longleftarrow \textbf{Ans}$$

4.3 The air flow to a four cylinder, four-stroke oil engine is measured by means of a 5 cm diameter orifice having a coefficient of discharge of 0.6. During a test on the engine the following data were recorded : bore = 10 cm; stroke = 12 cm; speed = 1200 rpm; brake torque = 120 Nm; fuel consumption = 5 kg/h; calorific value of fuel = 42 MJ/kg; pressure drop across orifice is 4.6 cm of water; ambient temperature and pressure are 17 °C and 1 bar respectively. Calculate (i) the thermal efficiency on brake power basis; (ii) the brake mean effective pressure and (iii) the volumetric efficiency based on free air condition.

Solution

$$bp = \frac{2\pi NT}{60000} = \frac{2 \times \pi \times 1200 \times 120}{60000} = 15.08 \text{ kW}$$

$$\eta_{bth} = \frac{15.08 \times 60}{\frac{5}{60} \times 42000} \times 100 = \mathbf{25.85\%} \quad \Longleftarrow \textbf{Ans}$$

$$p_{im} = \frac{bp \times 60000}{LAnK}$$

$$= \frac{15.08 \times 60000}{0.12 \times \frac{\pi}{4} \times 0.1^2 \times \frac{1200}{2} \times 4} = 4 \times 10^5 \text{ Pa} = \mathbf{4 \text{ bar}} \quad \Longleftarrow \textbf{Ans}$$

$$\dot{V}_a = C_d A \sqrt{2g\Delta h_w \frac{\rho_w}{\rho_a}}$$

$$\rho_a = \frac{p}{RT} = \frac{10^5}{287 \times 290} = 1.20 \text{ kg/m}^3$$

$$\dot{V}_a = 0.6 \times \frac{\pi}{4} \times 0.05^2 \times \sqrt{2 \times 9.81 \times 0.046 \times \frac{1000}{1.2}} \times 60$$

$$= 1.938 \text{ m}^3/\text{min}$$

$$V_s = \frac{\pi}{4} d^2 LnK$$

$$= \frac{\pi}{4} \times 0.1^2 \times 0.12 \times \frac{1200}{2} \times 4 = 2.262 \text{ m}^3/\text{min}$$

$$\eta_v = \frac{1.938}{2.262} \times 100 = \mathbf{85.7\%} \quad \Longleftarrow \textbf{Ans}$$

Extra notes:

External Evaluator