Program: B. Sc. Eng. in IPE (3rd)
Semester: Winter semester

Date: 03 October, 2023
Time: 10:30 am – 12:00 pm

ISLAMIC UNIVERSITY OF TECHNOLOGY (IUT)

ORGANISATION OF ISLAMIC COOPERATION (OIC)

DEPARTMENT OF MECHANICAL AND PRODUCTION ENGINEERING

Mid Semester Examination
Course Number: ME 4353
Course Title: Thermodynamics and Heat Transfer

Winter Semester: 2022 - 2023
Full Marks: 75
Time: 1.5 Hours

There are 3 (three) questions. Answer all 3 (three) questions.

The symbols have their usual meanings. Marks of each question and corresponding CO and PO are written in brackets. Assume reasonable value for any missing data. (Property tables are attached at page – 3)

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1. a) Consider the following specifications for a 4 – stroke engine having a bore-to-stroke ratio of 1.2. **(3x5=15) (CO2) (PO2)**

Configuration: V10	Volume: 3500 cc
Engine speed: 2800 rpm	Cut-off ratio: 1.75
Brake torque: 10.75 Nm	Clearance volume of a single cylinder: 0.018 L
Length of connecting rod: 300 mm	

Calculate:

i. Connecting rod to crank radius ratio.
ii. Mathematically whether the above-mentioned engine is a gasoline engine.
iii. The air standard efficiency (%) of the engine. ($k = 1.4$)
iv. The brake power (kW) at the flywheel.
v. The duration of each stroke (in milisec.).

b) "Methanol" is an alternative biofuel used in internal combustion engines which is safer for the environment than Gasoline. Its lower heating value is 19.9 MJ/kg. Answer the following – **(2x5=10) (CO2) (PO2)**

i. Calculate the air-fuel ratio of Methanol.
ii. Estimate the higher heating value (HHV) for Methanol.

2. a) Distinguish between 'air-cooled' and 'water-cooled' engines using at least 3 differences. Describe the function of a 'compression ring' mounted on the piston. **(6+2=8) (CO2) (PO1)**

b) Draw the following thermodynamic cycles – **(2x3=6) (CO2) (PO1)**

i. Carnot cycle in a T-S plane
ii. Otto cycle in a P-V plane
iii. Diesel cycle in a P-V plane

c) Draw the Actual Valve timing diagram for a 4-stroke Petrol Engine using proper notations and symbols. **(6) (CO2) (PO1)**

3. a) Justify the statement – "The thermal efficiency of a Heat Engine is always less than unity". Mention the key difference between a Heat Pump and a Refrigerator in terms of co-efficient of performance (COP). **(4+2=6) (CO1) (PO1)**

b) Describe "Point function" with example. How does an isentropic process differ from an adiabatic process? **(3+2=5) (CO1) (PO1)**

c) Consider the following scenarios and identify the exact form of energy for each scenario – **(4) (CO1) (PO1)**

i) Nuclear Fusion occurring in the Sun.
ii) A Honda Civic moves at 60 km/hr.
iii) Ice melts when it is kept outside.
iv) Lightning observed in the clouds.

d) A piston–cylinder device (see Fig. 1) initially contains 0.5 m^3 of nitrogen gas at 400 kPa and 27°C. An electric heater within the device is turned on and is allowed to pass a current of 2 A for 5 min from a 120-V source. Nitrogen expands at constant pressure, and a heat loss of 3000 J occurs during the process. Determine the final temperature of nitrogen. **(15) (CO1) (PO2)**

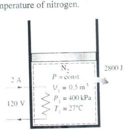

Figure 1. A piston-cylinder device

TABLE A–2

Ideal-gas specific heats of various common gases

(*a*) At 300 K

Gas	Formula	Gas constant, R kJ/kg·K	c_p kJ/kg·K	c_v kJ/kg·K	k
Air	—	0.2870	1.005	0.718	1.400
Argon	Ar	0.2081	0.5203	0.3122	1.667
Butane	C_4H_{10}	0.1433	1.7164	1.5734	1.091
Carbon dioxide	CO_2	0.1889	0.846	0.657	1.289
Carbon monoxide	CO	0.2968	1.040	0.744	1.400
Ethane	C_2H_6	0.2765	1.7662	1.4897	1.186
Ethylene	C_2H_4	0.2964	1.5482	1.2518	1.237
Helium	He	2.0769	5.1926	3.1156	1.667
Hydrogen	H_2	4.1240	14.307	10.183	1.405
Methane	CH_4	0.5182	2.2537	1.7354	1.299
Neon	Ne	0.4119	1.0299	0.6179	1.667
Nitrogen	N_2	0.2968	1.039	0.743	1.400

TABLE A–2

Ideal-gas specific heats of various common gases (*Continued*)

(*b*) At various temperatures

Temperature, K	c_p kJ/kg·K	c_v kJ/kg·K	k	c_p kJ/kg·K	c_v kJ/kg·K	k	c_p kJ/kg·K	c_v kJ/kg·K	k
	Air			*Carbon dioxide, CO_2*			*Carbon monoxide, CO*		
250	1.003	0.716	1.401	0.791	0.602	1.314	1.039	0.743	1.400
300	1.005	0.718	1.400	0.846	0.657	1.288	1.040	0.744	1.399
350	1.008	0.721	1.398	0.895	0.706	1.268	1.043	0.746	1.398
400	1.013	0.726	1.395	0.939	0.750	1.252	1.047	0.751	1.395
450	1.020	0.733	1.391	0.978	0.790	1.239	1.054	0.757	1.392
500	1.029	0.742	1.387	1.014	0.825	1.229	1.063	0.767	1.387
550	1.040	0.753	1.381	1.046	0.857	1.220	1.075	0.778	1.382
600	1.051	0.764	1.376	1.075	0.886	1.213	1.087	0.790	1.376
650	1.063	0.776	1.370	1.102	0.913	1.207	1.100	0.803	1.370
700	1.075	0.788	1.364	1.126	0.937	1.202	1.113	0.816	1.364
750	1.087	0.800	1.359	1.148	0.959	1.197	1.126	0.829	1.358
800	1.099	0.812	1.354	1.169	0.980	1.193	1.139	0.842	1.353
900	1.121	0.834	1.344	1.204	1.015	1.186	1.163	0.866	1.343
1000	1.142	0.855	1.336	1.234	1.045	1.181	1.185	0.888	1.335
	Hydrogen, H_2			*Nitrogen, N_2*			*Oxygen, O_2*		
250	14.051	9.927	1.416	1.039	0.742	1.400	0.913	0.653	1.398
300	14.307	10.183	1.405	1.039	0.743	1.400	0.918	0.658	1.395
350	14.427	10.302	1.400	1.041	0.744	1.399	0.928	0.668	1.389
400	14.476	10.352	1.398	1.044	0.747	1.397	0.941	0.681	1.382
450	14.501	10.377	1.398	1.049	0.752	1.395	0.956	0.696	1.373
500	14.513	10.389	1.397	1.056	0.759	1.391	0.972	0.712	1.365
550	14.530	10.405	1.396	1.065	0.768	1.387	0.988	0.728	1.358
600	14.546	10.422	1.396	1.075	0.778	1.382	1.003	0.743	1.350
650	14.571	10.447	1.395	1.086	0.789	1.376	1.017	0.758	1.343
700	14.604	10.480	1.394	1.098	0.801	1.371	1.031	0.771	1.337
750	14.645	10.521	1.392	1.110	0.813	1.365	1.043	0.783	1.332
800	14.695	10.570	1.390	1.121	0.825	1.360	1.054	0.794	1.327
900	14.822	10.698	1.385	1.145	0.849	1.349	1.074	0.814	1.319
1000	14.983	10.859	1.380	1.167	0.870	1.341	1.090	0.830	1.313