KOLEJ YAYASAN PELAJARAN JOHOR

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FINAL EXAMINATION

COURSE NAME	:	**THERMODYNAMICS**
COURSE CODE	:	**DKM 3203**
EXAMINATION	:	**JANUARY 2024**
DURATION	:	**3 HOURS**

INSTRUCTION TO CANDIDATES /
ARAHAN KEPADA CALON

1. This examination paper consists of **ONE (1)** part : / (100 Marks) /
   *Kertas soalan ini mengandungi **SATU (1)** bahagian:* *(100 Markah)*

2. Answer ALL questions in the answer sheet which is A4 size paper. /
   Jawab SEMUA soalan di dalam kertas jawapan iaitu kertas bersaiz A4.

3. Answers should be **neat and clear in handwritten form**. /
   Jawapan hendaklah ditulis tangan, kemas dan jelas.

DO NOT TURN THIS PAGE UNTIL YOU ARE TOLD TO DO SO /
JANGAN BUKA KERTAS SOALAN INI SEHINGGA DIBERITAHU

This examination paper consists of **11** printed pages including front page
*Kertas soalan ini mengandungi **11** halaman bercetak termasuk muka hadapan*

This part consists of **FOUR (4)** questions. Answer **ALL** the questions in the answer sheet.
*Bahagian ini mengandungi **EMPAT (4)** soalan. Jawab **SEMUA** soalan di dalam kertas jawapan.*

QUESTION 1/*SOALAN 1*

a. Convert the following units:

(i) 10 g/mm^3 to kg/m^3

(3 marks / *markah*)

(ii) 21 N/cm^2 to kN/m^2

(3 marks / *markah*)

(iii) 100 MN/m^2 to N/mm^2

(3 marks / *markah*)

Tukarkan unit berikut:

(i) 10 g/mm^3 kepada kg/m^3

(ii) 21 N/cm^2 kepada kN/m^2

(iii) 100 MN/m^2 kepada N/mm^2

b. Explain the following terms:

(i) System

(2 marks / *markah*)

(ii) Boundary

(2 marks / *markah*)

(iii) Surrounding

(2 marks / *markah*)

Terangkan istilah-istilah yang berikut:

(i) Sistem

(ii) Sempadan

(iii) Sekeliling

c. Steam at 1000 kPa as the specific internal energy 2480 kJ/kg. Calculate the:

(i) dryness fraction.
(3 marks / *markah*)

(ii) specific volume.
(3 marks / *markah*)

(iii) specific enthalpy.
(3 marks / *markah*)

(iv) sketch and locate the dryness fraction on the P-v diagram.
(1 marks /*markah*)

Stim pada tekanan 1000 kPa mempunyai tenaga dalamnya 2480 kJ/kg. Kirakan:

(i) pecahan kekeringan.

(ii) isi padu tentu.

(iii) entalpi tentu.

(iv) lakar dan tandakan titik pecahan kekeringan pada rajah P-v.

QUESTION 2/*SOALAN 2*

a. Air with mass of 0.65 kg at pressure 15 bar and temperature 230 °C is expanded until its is final volume is three times greater than its initial volume. The polytropic expansion process is according to the law $PV^n = C$. Calculate :
(Assume n = 1.37 and R = 0.287 kJ/kg.K)

(ii) the initial volume and final volume.
(4 marks / *markah*)

(iii) the final pressure (bar).
(3 marks / *markah*)

(iv) the final temperature.
(3 marks / *markah*)

(v) the work done.
(3 marks / *markah*)

Udara dengan jisim 0.65 kg pada tekanan 15 bar dan suhu 230 °C dikembangkan sehingga isipadu akhir adalah tiga kali ganda lebih besar daripada isipadu awal. Proses pengembangan politropik adalah mengikut hukun $PV^n = C$. Kirakan: (Anggapan n = 1.37 dan R = 0.287 kJ/kg.K)

(i) isipadu awal dan akhir.

(ii) tekanan akhir

(iii) suhu akhir

(iv) kerja yang dilakukan.

b. According to the steam table, at pressure of 1.25 MN/m^2, determine:

(i) saturation temperature.
(3 marks / *markah*)

(ii) specific liquid enthalpy.
(3 marks / *markah*)

(iii) specific enthalpy of evaporation.
(3 marks / *markah*)

(iv) specific enthalpy of dry saturated steam.
(3 marks / *markah*)

Berpandukan jadual stim, pada tekanan 1.25 MN/m^2, tentukan:

(i) suhu tepu

(ii) entalpi cair tentu

(iii) entalpi tentu penyejatan

(iv) entalpi tentu stim tepu kering

QUESTION 3/ *SOALAN 3*

a. List **four (4)** devices in open system.

*Senaraikan **empat (4)** peranti dalam sistem terbuka*

(4 marks / *markah*)

b. List **six (6)** forms of energy.

*Senaraikan **enam (6)** jenis bentuk tenaga.*

(6 marks / *markah*)

c. Steam flow steadily into a turbine at 6000 kg/h and produce 2400 kW of power output. Properties of steam for inlet and outlet part of the turbine are shown in the **Table 1** below. Assuming that changes in potential energy may be neglected, determine :

(i) heat which is transferred to surrounding in kW.

(11 marks / *markah*)

(ii) area of the outlet vessel.

(4 marks / *markah*)

*Stim mengalir secara mantap memasuki sebuah turbin dengan kadar 6000 kg/jam dan menghasilkan kuasa keluaran sebanyak 2400 kW. Keadaan stim pada bahagian masuk dan keluar dari turbin adalah seperti di **Jadual 1** di bawah. Jika perubahan tenaga keupayaan diabaikan, tentukan :*

(i) Haba yang dipindahkan ke persekitaran dalam kW.

(ii) luas permukaan bahagian keluar vessel.

	Inlet *Masukan*	Outlet *Keluaran*
Pressure, P ***Tekanan*** **(bar)**	9	1.5
Internal Energy, u ***Tenaga Dalam*** **(kJ/kg)**	3770	2550
Velocity, C ***Halaju Aliran*** **(m/s)**	320	110
Specific Volume, υ ***Isipadu Tentu*** **(m^3/kg)**	0.55	1.90

Table 1/ Jadual 1

QUESTION 4/*SOALAN 4*

a. Describe **four (4)** characteristics of heat engine

*Huraikan **empat (4)** ciri sebuah enjin haba.*

(4 marks / *markah*)

b. Heat is transferred to heat engine from the furnace at a rate of 255 GJ/hr. If the rate of waste heat rejection to a nearby river is 168 GJ/hr, determine:

(i) the net work done.

(5 marks / *markah*)

(ii) the thermal efficiency.

(3 marks / *markah*)

Haba dipindahkan ke enjin haba daripada relau pada kadar 255 GJ/jam. Jika kadar pembuangan haba ke sungai yang berhampiran adalah 168 GJ/jam, tentukan:

(i) kerja bersih yang dilakukan

(ii) kecekapan haba

c. A steam genarator is operated at a boiler pressure of 50 bar and condenser pressure of 0.05 bar. For a Carnot cycle, calculate :

(i) the thermal efficiency of the cycle.
(8 marks / *markah*)

(ii) heat supplied to the boiler.
(3 marks / *markah*)

(iii) sketch a complete T-s diagram.
(2 marks / *markah*)

Sebuah penjana stim yang bekerja antara tekanan dandang 50 bar dan tekanan pemeluwap 0.05 bar. Untuk kitar Carnot, kirakan :

(i) kecekapan haba kitaran.

(ii) haba bekalan dandang

(iii) lakar gambarajah T-s dengan lengkap.

[100 MARKS / *MARKAH*]

END OF THE QUESTION PAPER / *KERTAS SOALAN TAMAT*

FORMULA

1. FIRST LAW OF THERMODYNAMICS

$$\Sigma Q = \Sigma W \qquad Q - W = U_2 - U_1$$

2. FLOW PROCESS

$$\dot{m} = \rho V A = \frac{CA}{V}$$

$$Q - W = \dot{m}[(h_2 - h_1) + \left(\frac{C_2^2 - C_1^2}{2}\right) + g(Z_2 - Z_1) \qquad h = u + PV$$

3. PROPERTIES OF PURE SUBSTANCE

Steam

$$v = xv_g \quad u = h - Pv \qquad h = h_f + xh_{fg} \qquad s = s_f + xs_{fg} \qquad u = u_f + x(u_g - u_f)$$

Ideal Gas

$$PV = mRT \qquad R = \frac{R_o}{M} \qquad R = c_p - c_v \qquad \gamma = \frac{c_p}{c_v}$$

4. NON FLOW PROCESS

Isothermal Process $(PV = C)$

$$U_2 - U_1 = 0 \qquad Q = W \qquad W = P_1V_1 \ln\left(\frac{V_2}{V_1}\right) @ W = P_1V_1 \ln\left(\frac{P_1}{P_2}\right)$$

Adiabatic Process $(PV^\gamma = C)$

$$U_2 - U_1 = mc_v(T_2 - T_1) \quad Q = 0 \qquad W = \frac{P_1V_1 - P_2V_2}{\gamma - 1} = \frac{mR(T_2 - T_1)}{\gamma - 1}$$

$$\frac{T_2}{T_1} = \left(\frac{P_2}{P_1}\right)^{(\gamma-1)/\gamma} = \left(\frac{V_1}{V_2}\right)^{\gamma-1} \qquad \eta_{th,rev} = 1 - \frac{T_L}{T_H}$$

$$nisbah\ \text{ker}\ ja = \frac{\ln\frac{V_2}{V_1}(T_1 - T_3)}{T_1 \ln\frac{V_2}{V_1} + \frac{T_1 - T_3}{\gamma - 1}}$$

Isobaric Process

$$Q = mC_P(T_2 - T_1) \qquad W = P(V_2 - V_1) \qquad \Delta U = Q - W \qquad PV = mRT \qquad \frac{V_1}{T_1} = \frac{V_2}{T_2}$$

Isometric Process

$$Q = mC_v(T_2 - T_1) \qquad PV = mRT \qquad \frac{P_1}{T_1} = \frac{P_2}{T_2} \qquad \Delta U = Q$$

Polytropic Process $(PV^n = C)$

$$\frac{T_2}{T_1} = \left(\frac{P_2}{P_1}\right)^{\frac{n-1}{n}} = \left(\frac{V_1}{V_2}\right)^{n-1} \qquad U_2 - U_1 = mC_v(T_2 - T_1) \qquad Q = \frac{\gamma - n}{\gamma - 1} \text{ x } W \qquad W = \frac{P_1V_1 - P_2V_2}{n-1} = \frac{mR(T_1 - T_2)}{n-1}$$

$$P_1V_1^n = P_2V_2^n$$

5. SECOND LAW OF THERMODYNAMICS

Heat Engine

$$\eta_{th} = \frac{W_{net,\,out}}{Q_H} = 1 - \frac{Q_L}{Q_H}$$

Heat Pump

$$COP_{HP,\,rev} = \frac{T_H}{T_H - T_L} = \frac{1}{1 - \frac{T_L}{T_H}}$$

Power Cycle

$$\eta_{rankine} = \frac{w_T - w_p}{q_{in}} = \frac{(h_1 - h_2) - v_f(p_4 - p_3)}{(h_1 - h_4)}$$

$$\eta_{carnot} = \frac{(h_1 - h_2) - (h_4 - h_3)}{(h_1 - h_2)}$$

$$s.s.c_{rankine} = \frac{3600}{(h_1 - h_2) - v_f(p_4 - p_3)}$$

$$r_{w(rankine)} = \frac{(h_1 - h_2) - v_f(p_4 - p_3)}{(h_1 - h_2)}$$

TABLE A–5

Saturated water—Pressure table

		Specific volume, m^3/kg		*Internal energy,* kJ/kg			*Enthalpy,* kJ/kg			*Entropy,* kJ/kg · K		
Press., P kPa	Sat. temp., T_{sat} °C	Sat. liquid, v_f	Sat. vapor, v_g	Sat. liquid, u_f	Evap., u_{fg}	Sat. vapor, u_g	Sat. liquid, h_f	Evap., h_{fg}	Sat. vapor, h_g	Sat. liquid, s_f	Evap., s_{fg}	Sat. vapor, s_g
1.0	6.97	0.001000	129.19	29.302	2355.2	2384.5	29.303	2484.4	2513.7	0.1059	8.8690	8.9749
1.5	13.02	0.001001	87.964	54.686	2338.1	2392.8	54.688	2470.1	2524.7	0.1956	8.6314	8.8270
2.0	17.50	0.001001	66.990	73.431	2325.5	2398.9	73.433	2459.5	2532.9	0.2606	8.4621	8.7227
2.5	21.08	0.001002	54.242	88.422	2315.4	2403.8	88.424	2451.0	2539.4	0.3118	8.3302	8.6421
3.0	24.08	0.001003	45.654	100.98	2306.9	2407.9	100.98	2443.9	2544.8	0.3543	8.2222	8.5765
4.0	28.96	0.001004	34.791	121.39	2293.1	2414.5	121.39	2432.3	2553.7	0.4224	8.0510	8.4734
5.0	32.87	0.001005	28.185	137.75	2282.1	2419.8	137.75	2423.0	2560.7	0.4762	7.9176	8.3938
7.5	40.29	0.001008	19.233	168.74	2261.1	2429.8	168.75	2405.3	2574.0	0.5763	7.6738	8.2501
10	45.81	0.001010	14.670	191.79	2245.4	2437.2	191.81	2392.1	2583.9	0.6492	7.4996	8.1488
15	53.97	0.001014	10.020	225.93	2222.1	2448.0	225.94	2372.3	2598.3	0.7549	7.2522	8.0071
20	60.06	0.001017	7.6481	251.40	2204.6	2456.0	251.42	2357.5	2608.9	0.8320	7.0752	7.9073
25	64.96	0.001020	6.2034	271.93	2190.4	2462.4	271.96	2345.5	2617.5	0.8932	6.9370	7.8302
30	69.09	0.001022	5.2287	289.24	2178.5	2467.7	289.27	2335.3	2624.6	0.9441	6.8234	7.7675
40	75.86	0.001026	3.9933	317.58	2158.8	2476.3	317.62	2318.4	2636.1	1.0261	6.6430	7.6691
50	81.32	0.001030	3.2403	340.49	2142.7	2483.2	340.54	2304.7	2645.2	1.0912	6.5019	7.5931
75	91.76	0.001037	2.2172	384.36	2111.8	2496.1	384.44	2278.0	2662.4	1.2132	6.2426	7.4558
100	99.61	0.001043	1.6941	417.40	2088.2	2505.6	417.51	2257.5	2675.0	1.3028	6.0562	7.3589
101.325	99.97	0.001043	1.6734	418.95	2087.0	2506.0	419.06	2256.5	2675.6	1.3069	6.0476	7.3545
125	105.97	0.001048	1.3750	444.23	2068.8	2513.0	444.36	2240.6	2684.9	1.3741	5.9100	7.2841
150	111.35	0.001053	1.1594	466.97	2052.3	2519.2	467.13	2226.0	2693.1	1.4337	5.7894	7.2231
175	116.04	0.001057	1.0037	486.82	2037.7	2524.5	487.01	2213.1	2700.2	1.4850	5.6865	7.1716
200	120.21	0.001061	0.88578	504.50	2024.6	2529.1	504.71	2201.6	2706.3	1.5302	5.5968	7.1270
225	123.97	0.001064	0.79329	520.47	2012.7	2533.2	520.71	2191.0	2711.7	1.5706	5.5171	7.0877
250	127.41	0.001067	0.71873	535.08	2001.8	2536.8	535.35	2181.2	2716.5	1.6072	5.4453	7.0525
275	130.58	0.001070	0.65732	548.57	1991.6	2540.1	548.86	2172.0	2720.9	1.6408	5.3800	7.0207
300	133.52	0.001073	0.60582	561.11	1982.1	2543.2	561.43	2163.5	2724.9	1.6717	5.3200	6.9917
325	136.27	0.001076	0.56199	572.84	1973.1	2545.9	573.19	2155.4	2728.6	1.7005	5.2645	6.9650
350	138.86	0.001079	0.52422	583.89	1964.6	2548.5	584.26	2147.7	2732.0	1.7274	5.2128	6.9402
375	141.30	0.001081	0.49133	594.32	1956.6	2550.9	594.73	2140.4	2735.1	1.7526	5.1645	6.9171
400	143.61	0.001084	0.46242	604.22	1948.9	2553.1	604.66	2133.4	2738.1	1.7765	5.1191	6.8955
450	147.90	0.001088	0.41392	622.65	1934.5	2557.1	623.14	2120.3	2743.4	1.8205	5.0356	6.8561
500	151.83	0.001093	0.37483	639.54	1921.2	2560.7	640.09	2108.0	2748.1	1.8604	4.9603	6.8207
550	155.46	0.001097	0.34261	655.16	1908.8	2563.9	655.77	2096.6	2752.4	1.8970	4.8916	6.7886
600	158.83	0.001101	0.31560	669.72	1897.1	2566.8	670.38	2085.8	2756.2	1.9308	4.8285	6.7593
650	161.98	0.001104	0.29260	683.37	1886.1	2569.4	684.08	2075.5	2759.6	1.9623	4.7699	6.7322
700	164.95	0.001108	0.27278	696.23	1875.6	2571.8	697.00	2065.8	2762.8	1.9918	4.7153	6.7071
750	167.75	0.001111	0.25552	708.40	1865.6	2574.0	709.24	2056.4	2765.7	2.0195	4.6642	6.6837

TABLE A–5

Saturated water—Pressure table (*Continued*)

		Specific volume, m^3/kg		*Internal energy,* kJ/kg			*Enthalpy,* kJ/kg			*Entropy,* kJ/kg · K		
Press., P kPa	Sat. temp., T_{sat} °C	Sat. liquid, v_f	Sat. vapor, v_g	Sat. liquid, u_f	Evap., u_{fg}	Sat. vapor, u_g	Sat. liquid, h_f	Evap., h_{fg}	Sat. vapor, h_g	Sat. liquid, s_f	Evap., s_{fg}	Sat. vapor, s_g
800	170.41	0.001115	0.24035	719.97	1856.1	2576.0	720.87	2047.5	2768.3	2.0457	4.6160	6.6616
850	172.94	0.001118	0.22690	731.00	1846.9	2577.9	731.95	2038.8	2770.8	2.0705	4.5705	6.6409
900	175.35	0.001121	0.21489	741.55	1838.1	2579.6	742.56	2030.5	2773.0	2.0941	4.5273	6.6213
950	177.66	0.001124	0.20411	751.67	1829.6	2581.3	752.74	2022.4	2775.2	2.1166	4.4862	6.6027
1000	179.88	0.001127	0.19436	761.39	1821.4	2582.8	762.51	2014.6	2777.1	2.1381	4.4470	6.5850
1100	184.06	0.001133	0.17745	779.78	1805.7	2585.5	781.03	1999.6	2780.7	2.1785	4.3735	6.5520
1200	187.96	0.001138	0.16326	796.96	1790.9	2587.8	798.33	1985.4	2783.8	2.2159	4.3058	6.5217
1300	191.60	0.001144	0.15119	813.10	1776.8	2589.9	814.59	1971.9	2786.5	2.2508	4.2428	6.4936
1400	195.04	0.001149	0.14078	828.35	1763.4	2591.8	829.96	1958.9	2788.9	2.2835	4.1840	6.4675
1500	198.29	0.001154	0.13171	842.82	1750.6	2593.4	844.55	1946.4	2791.0	2.3143	4.1287	6.4430
1750	205.72	0.001166	0.11344	876.12	1720.6	2596.7	878.16	1917.1	2795.2	2.3844	4.0033	6.3877
2000	212.38	0.001177	0.099587	906.12	1693.0	2599.1	908.47	1889.8	2798.3	2.4467	3.8923	6.3390
2250	218.41	0.001187	0.088717	933.54	1667.3	2600.9	936.21	1864.3	2800.5	2.5029	3.7926	6.2954
2500	223.95	0.001197	0.079952	958.87	1643.2	2602.1	961.87	1840.1	2801.9	2.5542	3.7016	6.2558
3000	233.85	0.001217	0.066667	1004.6	1598.5	2603.2	1008.3	1794.9	2803.2	2.6454	3.5402	6.1856
3500	242.56	0.001235	0.057061	1045.4	1557.6	2603.0	1049.7	1753.0	2802.7	2.7253	3.3991	6.1244
4000	250.35	0.001252	0.049779	1082.4	1519.3	2601.7	1087.4	1713.5	2800.8	2.7966	3.2731	6.0696
5000	263.94	0.001286	0.039448	1148.1	1448.9	2597.0	1154.5	1639.7	2794.2	2.9207	3.0530	5.9737
6000	275.59	0.001319	0.032449	1205.8	1384.1	2589.9	1213.8	1570.9	2784.6	3.0275	2.8627	5.8902
7000	285.83	0.001352	0.027378	1258.0	1323.0	2581.0	1267.5	1505.2	2772.6	3.1220	2.6927	5.8148
8000	295.01	0.001384	0.023525	1306.0	1264.5	2570.5	1317.1	1441.6	2758.7	3.2077	2.5373	5.7450
9000	303.35	0.001418	0.020489	1350.9	1207.6	2558.5	1363.7	1379.3	2742.9	3.2866	2.3925	5.6791
10,000	311.00	0.001452	0.018028	1393.3	1151.8	2545.2	1407.8	1317.6	2725.5	3.3603	2.2556	5.6159
11,000	318.08	0.001488	0.015988	1433.9	1096.6	2530.4	1450.2	1256.1	2706.3	3.4299	2.1245	5.5544
12,000	324.68	0.001526	0.014264	1473.0	1041.3	2514.3	1491.3	1194.1	2685.4	3.4964	1.9975	5.4939
13,000	330.85	0.001566	0.012781	1511.0	985.5	2496.6	1531.4	1131.3	2662.7	3.5606	1.8730	5.4336
14,000	336.67	0.001610	0.011487	1548.4	928.7	2477.1	1571.0	1067.0	2637.9	3.6232	1.7497	5.3728
15,000	342.16	0.001657	0.010341	1585.5	870.3	2455.7	1610.3	1000.5	2610.8	3.6848	1.6261	5.3108
16,000	347.36	0.001710	0.009312	1622.6	809.4	2432.0	1649.9	931.1	2581.0	3.7461	1.5005	5.2466
17,000	352.29	0.001770	0.008374	1660.2	745.1	2405.4	1690.3	857.4	2547.7	3.8082	1.3709	5.1791
18,000	356.99	0.001840	0.007504	1699.1	675.9	2375.0	1732.2	777.8	2510.0	3.8720	1.2343	5.1064
19,000	361.47	0.001926	0.006677	1740.3	598.9	2339.2	1776.8	689.2	2466.0	3.9396	1.0860	5.0256
20,000	365.75	0.002038	0.005862	1785.8	509.0	2294.8	1826.6	585.5	2412.1	4.0146	0.9164	4.9310
21,000	369.83	0.002207	0.004994	1841.6	391.9	2233.5	1888.0	450.4	2338.4	4.1071	0.7005	4.8076
22,000	373.71	0.002703	0.003644	1951.7	140.8	2092.4	2011.1	161.5	2172.6	4.2942	0.2496	4.5439
22,064	373.95	0.003106	0.003106	2015.7	0	2015.7	2084.3	0	2084.3	4.4070	0	4.4070