Md Mustafa Rn
7.1.13

L-2/T-1/ME **Date : 07/01/2013**

BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY, DHAKA

L-2/T-1 B. Sc. Engineering Examinations 2011-2012

Sub : **EEE 259** (Electrical and Electronic Technology)

Full Marks : 280 Time : 3 Hours

The figures in the margin indicate full marks.

USE SEPARATE SCRIPTS FOR EACH SECTION

SECTION – A

There are **FOUR** questions in this section. Answer any **THREE**.

1. (a) A three phase, Y connected, abc sequence voltage source is supplying a three phase load having impedance $12 + j9\ \Omega$ in each phase. If the line impedance is $0.06 + j0.12\ \Omega$ in each line connecting the source and load, determine line and phase currents, line and phase voltages both for source and load side. Given, the load is Y connected. **($30\frac{2}{3}$)**

   (b) Make a free hand plot of signal vs. time of the following two signals: **(7)**

   (i) $x_1 = A_1 \sin \omega t$, (ii) $x_2 = A_2 \cos(\omega t - 60°)$ $(A_1 = 2A_2)$

   From this plot determine which signal is leading with proper reasoning.

   (c) Draw the vector diagram of the following signals: **(9)**

   (i) $x_1 = A_1 \sin(\omega t + 30°)$, (ii) $x_2 = A_2 \sin(\omega t - 30°)$,

   (iii) $x_3 = A_3 \sin(90° - \omega t)$, (iv) $x_4 = x_1 + x_2 - x_3$

2. (a) Derive the approximate equivalent circuit referred to primary of a transformer. **(12)**

   (b) The equivalent circuit impedances of a 20 kVA, 4000/240 V, 60 Hz transformer are to be determined. The open circuit test and short circuit test were performed on the primary side of the transformer and the following data were taken: **($23\frac{2}{3}$)**

Open circuit test (on Primary)	Short circuit test (on Primary)
$V_{OC} = 4000$ V	$V_{SC} = 489$ V
$I_{OC} = 0.214$ A	$I_{SC} = 2.5$ A
$P_{OC} = 400$ W	$P_{SC} = 240$ W

   Find the impedances of the approximate equivalent circuit referred to the secondary side and sketch that circuit.

   (c) Draw the phasor diagram of a transformer operating at a lagging power factor, unity power factor and a leading power factor. In which case the voltage regulation will be positive? **(11)**

Contd P/2

25

EEE 259 (ME)

3. (a) Derive the equivalent circuit of a synchronous generator. **(12)**

(b) Show graphically, the open circuit and short circuit characteristics of a synchronous generator. How can we determine the synchronous reactance at a given field current from these characteristics? **(18)**

(c) A synchronous generator is supplying a load. A second is to be connected in parallel with the first one. The generator has a no-load frequency of 61 Hz and a slope of 1 MW/Hz. The first load consumes a real power of 1000 kW at 0.8 pf lagging, while the second load consumes a real power of 800 kW at 0.707 pf lagging. **($16\frac{2}{3}$)**

(i) Before the second load is connected, what is the operating frequency of the system?

(ii) After the second load is connected, what is the operating frequency of the system?

4. (a) Discuss armature current versus field current characteristics of a synchronous motor. Why is it shaped like 'V'? **(15)**

(b) How is synchronous motor used for power factor correction? **(15)**

(c) Discuss the starting problems of a synchronous motor. How can we overcome these problems? **($16\frac{2}{3}$)**

SECTION – B

There are **FOUR** questions in this section. Answer any **THREE**.

5. (a) Discuss the current-voltage characteristics of the shunt, series, cumulatively compounded and differentially compounded DC generators. **(20)**

(b) A 5-hp, 1500 rpm, 2-pole DC series motor is running at 3% less than the rated speed supplying 2% more than the rated load. If induced voltage is 240 V, armature resistance is 10 Ω, field resistance is 2 Ω, then what is the input voltage? If the output torque is raised 5% due to increased load, while keeping the speed of rotation same as before, determine the armature current assuming the same induced voltage as before. **($26\frac{2}{3}$)**

6. (a) A 480 V, 60 Hz, 50-hp, 3-ϕ induction motor is drawing 60 A at 0.85 pf lagging. The stator copper losses are 2 kW, the rotor copper losses are 700 W, the friction and windage losses are 600 W, the core losses are 1.8 kW and the stray losses are negligible. Find (i) the air gap power; (ii) the output power and (iii) the efficiency of the motor. **($24\frac{2}{3}$)**

(b) Draw the torque-speed characteristics of an induction motor showing the starting torque, pull-out torque and rated torque. **(12)**

(c) What is transducer? Classify transducers. What are primary and secondary transducers? Give examples. **(10)**

Contd P/3

EE 259 (ME)

7. (a) What are the differences between voltage amplifiers and power amplifiers? Classify power amplifiers. **(10)**

(b) Briefly describe how a transistor can be used as an amplifier. **(15)**

(c) For the circuit shown in Fig. for Q. 7(c), if an input signal v_i is applied such that the peak-to-peak variation of the base current is 0.01 mA, then draw the output voltage vs. time curve. Also, explain the slope of the curve. **($21\frac{2}{3}$)**

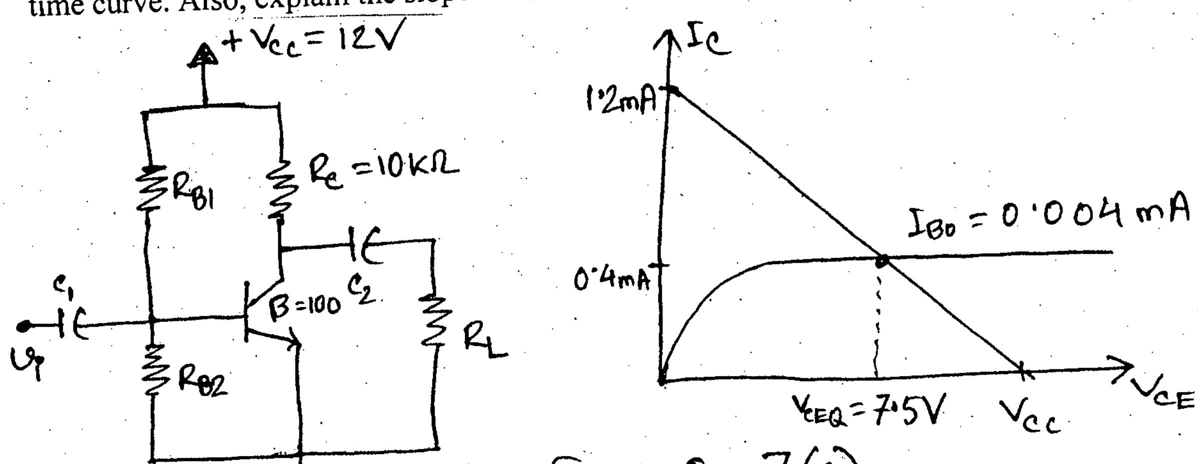

Fig. for Q. 7(c)

8. (a) Draw the circuit diagram of a full-wave bridge rectifier and explain its operation. **(15)**

(b) For the circuit shown in Fig. for Q. 8(b), plot the output voltage vs. time curve. Assume forward voltage drop of each diode is 0.7 V. **(15)**

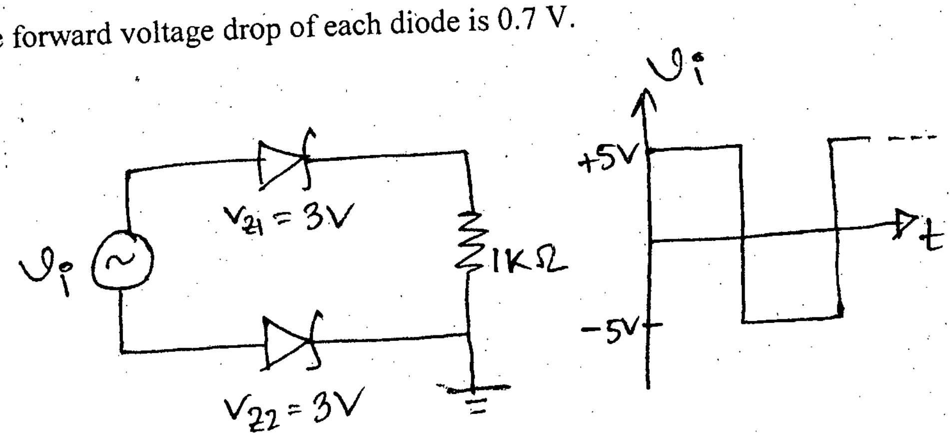

Fig. for Q. 8(b)

(c) For the circuit shown in Fig. for Q. 8(c), calculate the base, emitter and collector currents. **($16\frac{2}{3}$)**

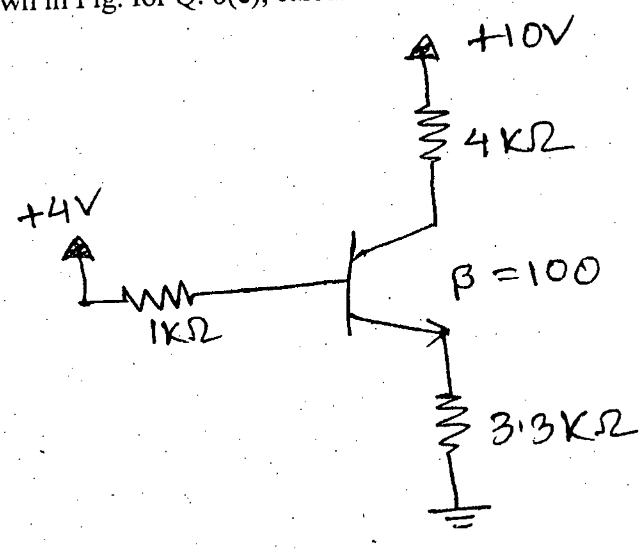

Fig. for Q. 8(c)

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L-2/T-1/ME

Date : 24/12/2012

BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY, DHAKA

L-2/T-1 B. Sc. Engineering Examinations 2011-2012

Sub : **HUM 303** (Principles of Accounting)

Full Marks : 210 Time : 3 Hours

The figures in the margin indicate full marks.

USE SEPARATE SCRIPTS FOR EACH SECTION

SECTION – A

There are **FOUR** questions in this section. Answer any **THREE**.

1. (a) Explain the basic accounting equation: Assets (A) = Liabilities (L) + Owner's Equity (OE) with examples. **(5)**

   (b) What is trial balance? Describe the advantages and disadvantages of trial balance. **(5)**

   (c) Mr. Akhand and his associates started their manufacturing business on August 1, 2012. The following transactions took place during the first month of operation: **(25)**

August 1	:	Invested Tk. 90,000 in cash to start business.
August 7	:	Purchased office equipment in cash amount Tk. 120,000.
August 10	:	Hired a managing director to manage the business efficiency. He will be paid to salary Tk. 20,000 per month.
August 18	:	Incurred advertising expanse on account as Tk. 5,000.
August 20	:	Incurred office rent in advanced as Tk. 10,000.
August 21	:	Earned Tk. 30,000 for selling the product, Tk. 10,000 is received in cash and remaining on account.
August 23	:	Withdrawn by Mr. Khan for his personal use as Tk. 5,000.
August 25	:	Paid the amount due related to advertising expanse.
August 27	:	Received cash from previous customer on transaction August 21.
August 31	:	Employees' salaries expanse was due for Tk. 4,000.

   Requirement:
   Provide journal entries for above transactions.

2. (a) Discuss the objectives and importance of financial statements analysis. **(3)**

   (b) State qualitative characteristics and four principles to provide financial information with examples briefly. **(7)**

   (c) The following information taken from the financial statements of Eastern Housing Ltd. **(15)**

Net Sales	Tk. 50,000
Gross Profit	Tk. 12,500
Net Profit	Tk. 6,500
Owner's Equity:	
01. 01. 2011	Tk. 40,000
31. 12. 2011	Tk. 30,000
Total Assets:	
01. 01. 2011	Tk. 62,000
31. 12. 2011	Tk. 60,000

Contd P/2

HUM 303

Contd ... Q. No. 2(c)

Required:

(i) Calculate profit ratio
(ii) Calculate Goss profit ratio
(iii) Compute Return on Equity (ROE)
(iv) Compute Return on Assets (ROA)
(v) Compute Equity ratio

(d) The following are selected items from a recent balance sheet of XYZ company: **(10)**

Cash and Cash equivalents	Tk. 6000
Short term investment	Tk. 4000
Gross Accounts receivable	Tk. 8000
Allowance for doubtful debt	Tk. 1000
Merchandise inventory	Tk. 4500
Prepaid expenses	Tk. 4000
Accounts payable	Tk. 8000
Notes payable	Tk. 2000
Accured expenses	Tk. 1200

Required: Compute (i) Current ratio, (ii) Quick ratio and (iii) Working capital amount.

3. Green View limited has the following information taken as trial balance on 31st December, 2011.

Name of Accounts	Debit (Tk.)	Credit (Tk.)
Cash	8,000	
Accounts Receivable	36,000	
Allowance for uncollectible	---	4,800
Supplies	6,500	
Prepaid expense	8,000	
Inventory (01. 01. 2011)	94,000	
Office equipment	50,000	
Accumulated depreciation – Office equipment	---	10,000
Purchase	170,000	
Purchase Return	---	13,200
Sales Revenue	---	300,000
Sales Return	50,000	
Rent Expense	60,000	
Salary Expense	49,000	
Accounts payable	---	25,000
Notes payable	---	8,000
Advertising Expense	28,000	
Capital		198,500
Total	559500	559500

HUM 303

Contd ... Q. No. 3

Information for Adjustments:

(i) Estimated uncollectible account expense Tk. 2000
(ii) Supplies consumed during the period Tk. 3000
(iii) Prepaid expense is expired Tk. 2,200
(iv) Inventory on December 31, 2011 is Tk. 85,000
(v) Estimated depreciation for office equipment at the rate of 10% per year
(vi) Interest expense is accrued Tk. 1500
(vi) Advertising expense is accrued Tk. 5,000

Requirements:

(a) Show the necessary adjusting entries. **(15)**
(b) Prepare adjusted trial balance. **(20)**

4. The following is the trial balance of Tom Company as on 31st December, 2011.

	Debit (Tk.)	Credit (Tk.)
Sales revenue	---	50,000
Merchandise inventory (01. 01. 11)	6,000	
Purchase	24,000	
Purchase return	---	1,000
Sales discounts	2,500	
Accounts receivable	20,000	
Accounts payable	---	14,000
Capital	---	40,000
Drawings	10,000	
Salaries	8,000	
Supplies	3,000	
Delivery Van	20,000	
Cash	9,300	
Prepaid insurance	2,200	
Total	105,000	105,000

Other information:

(i) Supplies used Tk. 1,200
(ii) Depreciation on delivery Van is Tk. 2,000
(iii) Merchandise inventory on 31st December, 2011 was Tk. 5,500
(iv) Tk. 2,500 of accounts receivable was uncollectible
(v) Salaries were accrued Tk. 4,000
(vi) Insurance expense was Tk. 2,000

<u>Required</u>:

(a) Prepare multiple income statement for the period ended on 31st December, 2011. **(15)**
(b) Prepare statement of Owner's Equity and Balance Sheet as on 31st December, 2011. **(20)**

Contd P/4

HUM 303

SECTION – B

There are **FOUR** questions in this section. Answer any **THREE**.

5. (a) What is meant by a product's CM ratio? How is this ratio useful in planning business operations? **(5)**

(b) Quality Products manufacture plastic football. The selling price is Tk. 37.50 per unit and variable cost is Tk. 22.50 per unit. Over the past year company sold 40,000 units of football, with the following results: **(30)**

Sales (40,000 footballs)	Tk. 1,500,000
Less: Variable expenses	Tk. 900,000
Contribution Margin	Tk. 600,000
Less: Fixed expenses	Tk. 480,000
Net Operating Income	Tk. 120,000

Required:

(i) Compute CM ratio and break -even point in units and sales Taka. Also compute degree of operating leverage of sales.

(ii) The company estimates that, in the next year variable cost will increase by Tk. 3 per football. The selling price will remain constant at Tk. 37.50 per football. What will be the new CM ratio and the new break-even point in units and sales Taka.

(iii) Refer to the data (ii) above if the expected change in variable costs take place how many footballs will have to be sold to earn the same net operating income (Tk. 120,000) as last year?

(iv) Refer to the original data. Assume that will decrease variable cost by 40% but fixed cost will increase by 90%. What would be the new CM ratio and break-even point in units and sales Taka?

(v) Refer to the data in (iv) above. Assume that in next year company will sell 50,000 units of football. Compute –

Contribution margin income statement and Margin of safety in units.

6. (a) Explain how fixed manufacturing overhead costs are shifted from one period to another under absorption costing. **(5)**

(b) Advance Products Company manufactures and sells a single product. You have been given the following information: **(30)**

Particulars	Amount (Tk.)
Variable cost per unit:	
Direct materials	18
Direct labor	7
Variable manufacturing overhead	2
Variable selling and administrative	5
Fixed costs per year:	
Fixed manufacturing overhead	160,000
Fixed selling and administrative expense	110,000

Contd P/5

HUM 303

Contd ... Q. No. 6(b)

During the year, the company produced 20,000 units and sold 16,000 units. The selling price of per unit is Tk. 50.

Required:

(i) Compute the unit product cost under absorption costing and variable costing.

(ii) Prepare income statement under both of the techniques.

7. (a) What are the purposes of cost allocation? **(5)**

(b) Navana Company has two support departments – Administrative Services (AS) and Information Systems (IS) and two operating departments – Government Consulting (GOVT) and Corporate Consulting (CORP). For the first quarter of 2012, the following records are available **(30)**

Navana Company

For the first quarter, 2012

	Support Dept.		Operating Dept.		Total
	AS	IS	GOVT	CORP	
Budgeted overhead before allocation	600,000	2,400,000	8,756,000	12,452,000	24,208,000
Support work supplied by AS	---	25%	40%	35%	100%
Support work supplied by IS	10%	---	30%	60%	100%

Required:

Allocate the two support departments cost to the two operating departments by using

(i) Direct method

(ii) Step-down method

(iii) Receiprocal method

8. (a) What are the objectives of cost accounting? **(5)**

(b) Following information are available for Doel company at December 31, 2012. **(15)**

Doel Company

December 31, 2012

Particulars	Beginning Inventory Amount (Tk.)	Ending Inventory Amount (Tk.)
Raw material	3,200	2,500
Work-in-process	1,350	1,700
Finished goods	8,500	9,500

Contd P/6

L-2/T-1/ME **Date : 31/12/2012**

BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY, DHAKA

L-2/T-1 B. Sc. Engineering Examinations 2011-2012

Sub : **MATH 261** (Vector Calculus, Matrices, Laplace Transform and Series Solution)

Full Marks : 280 Time : 3 Hours

The figures in the margin indicate full marks.

Symbols used have their usual meaning.

USE SEPARATE SCRIPTS FOR EACH SECTION

SECTION – A

There are **FOUR** questions in this section. Answer any **THREE**.

1. (a) Find the value of k for which the following system of equations has non-trivial solutions. Also find the solutions. **($16\frac{2}{3}$)**

$$x + ky + 3z = 0$$
$$4x + 3y + kz = 0$$
$$2x + y + 2z = 0$$

(b) Examine the following system of vectors for linear dependence. If dependent, find the relation among them. **(15)**

$X_1 = (1, 1, -1, 1)$, $X_2 = (1, -1, 2, -1)$ and $X_3 = (3, 1, 0, 1)$.

(c) Use Cayley-Hamilton theorem to find the inverse of the matrix **(15)**

$$A = \begin{pmatrix} 1 & 2 & -2 \\ 1 & 1 & 1 \\ 1 & 3 & -1 \end{pmatrix}.$$

2. (a) Find a matrix P which diagonalizes the matrix $A = \begin{pmatrix} 1 & 0 & -1 \\ 1 & 2 & 1 \\ 2 & 2 & 3 \end{pmatrix}$. Write down the diagonal form of A and also find A^4. **($23\frac{2}{3}$)**

(b) Express the following quadratic form as a sum of the squares and classify it as definite, semi-definite or indefinite: **(23)**

$$q = 4x_1^2 + 3x_2^2 - x_3^2 + 2x_2x_3 - 4x_3x_1 + 4x_1x_2.$$

Also write down the equations of linear transformation and find a non-trivial set of values of x_1, x_2, x_3 which makes the form zero.

3. (a) Find $\underline{A} \times (\nabla \times \underline{B})$ and $(\underline{A} \times \nabla) \times \underline{B}$ at the point (1, –1, 2) if $\underline{A} = xz^2\hat{i} + 2y\hat{j} - 3xz\hat{k}$ and $\underline{B} = 3xz\hat{i} + 2yz\hat{j} - z^2\hat{k}$. **(16)**

(b) Show that curl (curl $\underline{F}$) = grad div$\underline{F} - \nabla^2\underline{F}$ and hence show that $\nabla^2\underline{F} = n(n+3)r^{n-2}\underline{r}$ where $\underline{F} = r^n\underline{r}$. **($20\frac{2}{3}$)**

(c) Use Green's theorem to find the area bounded by the hypocycloid **(10)**

$$x^{2/3} + y^{2/3} = a^{2/3}; \quad a > 0.$$

Contd P/2

MATH 261

4. (a) Show that **(20)**

$$\underline{F} = (6xyz + z^2)\hat{i} + 3x^2z\hat{j} + (3x^2y + 2xz)\hat{k}$$

is a conservative force field. Find the scalar potential of this field and the work done in moving an object in this field from the point (2, −2, 2) to (2, −1, 3).

(b) State Gauss's divergence theorem, Verify the theorem for **($26\frac{2}{3}$)**

$$\underline{F} = 2x^2y\hat{i} - y^2\hat{j} + 4xz^2\hat{k}$$

taken over the region in the first octant bounded by $y^2 + z^2 = 9$ and $x = 2$.

SECTION – B

There are **FOUR** questions in this section. Answer any **THREE**.

5. (a) Solve the Bessel's differential equation **(36)**

$$x^2y'' + xy' + (x^2 - n^2)y = 0$$

by the method of Fröbenius.

(b) When n is positive integer, show that $J_{-n}(x) = (-1)^n J_n(x)$. **($10\frac{2}{3}$)**

6. Show that

(i) $\int_0^x x^{-n} J_{n+1}(x)\,dx = \frac{1}{2^n \lfloor n} - x^{-n} J_n(x)$. **($16\frac{2}{3}$)**

(ii) $P_n(x) = \frac{1}{2^n \lfloor n} \frac{d^n}{dx^n}\left(x^2 - 1\right)^n$. **(20)**

(iii) $P_{2n}(0) = (-1)^n \frac{1.3.5...(2n-1)}{2.4.6....2n}$. **(10)**

7. (a) Show that $\int_{-1}^{1} P_m(x) P_n(x)\,dx = \begin{cases} 0 & \text{if } m \neq n \\ \frac{2}{2n+1} & \text{if } m = n \end{cases}$. **(20)**

(b) Evaluate $L\{J_0(at)\}$ and $L\{J_1(at)\}$. **(14)**

(c) Using Laplace transformation, show that $Si(\infty) = \frac{\pi}{2}$. **($12\frac{2}{3}$)**

8. (a) Using Laplace transformation, show that $J_0(t) = \frac{1}{\pi}\int_0^{\pi} \cos(t\cos\theta)\,d\theta$. **($12\frac{2}{3}$)**

(b) Find (i) $L^{-1}\left\{\frac{se^{-4\pi s/5}}{s^2 + 25}\right\}$ (ii) $L^{-1}\left\{\frac{e^{4-3s}}{(s+4)^{5/2}}\right\}$. **(14)**

(c) Solve (using Laplace Transformation) **(20)**

$$Y''(t) - tY'(t) + Y(t) = 1, \quad Y(0) = 1,\ Y'(0) = 2.$$

L-2/T-1/ME **Date : 17/12/2012**

BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY, DHAKA

L-2/T-1 B. Sc. Engineering Examinations 2011-2012

Sub : **ME 201** (Basic Thermodynamics)

Full Marks : 280 Time : 3 Hours

The figures in the margin indicate full marks.

USE SEPARATE SCRIPTS FOR EACH SECTION

SECTION – A

There are **FOUR** questions in this section. Answer any **THREE**.

Steam table R-134a properties are supplied.

1. (a) Briefly explain 'thermodynamic equilibrium' and 'quasi-static process'. **(10)**

   (b) With a suitable diagram, show that work is a path function. Mention some similarities between 'work' and 'heat'. **(15)**

   (c) Draw a typical P-T diagram of a pure substance and label it. Briefly explain the physical meanings of (i) critical point (ii) triple point. **(15)**

   (d) One kg of air is compressed reversibly and isothermally from 0.1 MPa and 27 °C to 1.0 MPa. Assuming ideal gas, estimate work done and heat transfer during this process. **($6\frac{2}{3}$)**

2. (a) Using 'First Law of thermodynamics', show that internal energy is a thermodynamic property. Briefly explain the physical meaning of 'internal energy and how it differs from 'entropy'. **(10)**

   (b) With schematic diagrams and proper assumptions, simplify the 1st Law of thermodynamics for the following devices: **(15)**

   (i) Nozzle
   (ii) Heat exchanger
   (iii) Throttling device

   (c) Briefly explain Joule's free expansion experiment and show that, u = f(T) for ideal gases. **(10)**

   (d) Air initially at 1 bar and 27 °C is compressed in steady state to 5 bars and 177 °C. The power input to the compressor is 5 kW and heat loss is 0.5 kW. If the changes in potential and kinetic energies are neglected. Estimate mass flow rate of air. **($11\frac{2}{3}$)**

3. (a) Briefly present Kelvin-Planck (KP) and Clausius (C) statements of the second law of thermodynamics. Show that, any violation of Clausius statement implies the violation of KP statement. **(10)**

   (b) Show that, $\eta_{rev} > \eta_{irrev}$. **(10)**

   (c) Distinguish between perpetual motion machine of 1st kind and 2nd kind. **(10)**

   (d) Dry saturated steam at 10 MPa expands isothermally and reversibly to 1.0 MPa. Calculate the heat supply and work done per kg of steam during the process. **(10)**

Contd P/2

Contd ... Q. No. 3

(e) Suppose that, 1 kg of saturated vapor at 100 °C is converted to saturated liquid at 100 °C in an isobaric process. If the surrounding air is at 300 K, estimate net change in entropy of the system plus surroundings. **($6\frac{2}{3}$)**

4. (a) Show that, $C_p - C_v = \frac{\beta^2}{kT} . vT$ **(15)**

where kT = isothermal compressibility, and

β = volume expansivity

(b) Using the expression of 4(a), show that for ideal gas, $C_p - C_v = R$. **(5)**

(c) What is the difference between saturated liquid and compressed liquid? **(5)**

(d) A system undergoes a process between two states: first in a reversible manner and then in an irreversible manner. For which case is the entropy change greater? Why? **(5)**

(e) The entropy of hot water decreases as it cools. Is this a violation of increase of entropy principle? **(5)**

(f) An insulated rigid tank is divided into two equal parts by a membrane. Air is contained in one half and the other half is evacuated. The membrane is punctured and air quickly fills the entire volume. Explain the work done and entropy generation in the process. **($11\frac{2}{3}$)**

SECTION – B

There are **FOUR** questions in this section. Answer any **THREE**.

Make reasonable assumptions in case of any missing data.

Symbols indicate their usual meaning.

5. (a) Write short note on Binary Vapor Power Cycle. Provide component-wise schematic and corresponding T-s diagram. **(10)**

(b) A steam power plant operates on an ideal reheat-regenerative Rankine cycle with one reheater and one open feed water heater. Steam enters the HP turbine at 10 MPa and 600°C and leaves the LP turbine at 8 kPa. Steam is extracted from the turbine at 2.0 MPa and it is reheated to 550°C at a pressure 0.8 MPa. Water leaves the feed water heater as saturated liquid. Heat is transferred to the steam in the boiler at a rate of 630 MW. Determine (i) the mass flow rate of steam through the boiler, (ii) the net power output (iii) the thermal efficiency of the cycle. **(30)**

(c) The plant engineer is thinking about discarding the condenser. He instead plans to pump water at atmospheric pressure to the boiler and expel steam out from the turbine at atmospheric pressure for he thinks of the condenser as a wastage of energy since it is only condensing steam and may be using a separate cooling tower for itself. However, you have reasons to believe that condenser is a necessary component for augmenting work output. Substantiate your reasoning with appropriate T-s diagram. What are the theoretical and practical limits of condenser pressure? **($6\frac{2}{3}$)**

Contd P/3

6. (a) For an air-standard ideal diesel cycle with compression ratio "r_c", cut-off ratio "β", and ratio of specific heats of air "k", show that the thermal efficiency, **(15)**

$$\eta_{th,diesel} = 1 - (r_c)^{1-k}\left[\frac{(\beta^k - 1)}{k(\beta - 1)}\right]$$

(b) Calculate net work output per unit mass of air, back work ratio and thermal efficiency for a Brayton cycle with one stage reheating and one stage intercooling, where air enters the compressor at 300 K and 100 kPa, and enters the turbine at 1400 K and 1300 kPa. Turbines and compressors are isentropic. The regenerator effectiveness is 0.75. Take k = 1.4 and C_p = 1.005 kJ/kg-K. **(25)**

(c) A simple gas turbine is working on the ideal Brayton cycle with a maximum cycle temperature T_3 and minimum cycle temperature T_1. Show that, pressure ratio (r_p) for maximum net work should be, **(5+1 $\frac{2}{3}$)**

$$r_p = \left(\frac{T_3}{T_1}\right)^{k/2(k-1)}$$

Will the cycle efficiency be maximum at this pressure ratio as well?

7. (a) List the deviations of actual vapor compression refrigeration cycle from the ideal one. Identify them on the P-h diagram. **(6 $\frac{2}{3}$)**

(b) The initial conditions for an air-standard ideal Otto cycle operating with a compression ratio of 8:1 are 0.95 bar and 17°C. At the beginning of the compression stroke, the cylinder volume is 2.20 L, and 3.60 kJ of heat is added during the heating process. Calculate the pressure and temperature at the end of each process of the cycle, and determine the thermal efficiency and the MEP. **(15)**

(c) A commercial refrigerator with refrigerant R134a as the working fluid is used to keep the refrigerated space at 5°C by rejecting its waste heat to cooling water that enters the condenser at 17°C at a rate of 0.2 kg/s and leaves at 25°C. The refrigerant enters the condenser at 1.4 MPa and leaves at the same pressure at 42°C. The inlet state of the isentropic compressor is at 100 KPa and – 20°C. Determine (a) the quality of the refrigerant at the evaporator inlet, (b) the refrigeration load in tons, and (c) the COP of the refrigerator. **(25)**

Contd P/4

8\. (a) Define ton of refrigeration. $(1\frac{2}{3})$

(b) For a dry bulb temperature of 25°C and wet bulb temperature of 15°C, determine the absolute humidity (ω), relative humidity (ϕ), and mixture enthalpy (h) in kJ/kg of dry air at a pressure of 0.5 bar. **(15)**

(c) A mixture consists of 19.23 percent carbon dioxide, 8.86 percent water vapor and 71.91 percent nitrogen by mass. The mixture is being maintained at 298 K and 1 bar where under ideal gas assumptions the enthalpies of the gases are known (h_{CO_2} = 9364 kJ/kmol, h_{H_2O} = 9904 kJ/kmol, h_{N_2} = 8669 kJ/kmol). Determine (a) the specific enthalpy of the mixture in kJ/kmol, and (b) apparent gas constant of the mixture in kJ/kg-K. **(15)**

(d) Write down the stoichiometric combustion equation of n-Octane with air at 1 atm and 25°C and calculate the LHV and HHV of n-Octane for a complete combustion using data from the following table: **(15)**

Substance	Formula	Δh_f^0 (MJ/kmol)	h_{fg} (MJ/kmol)
Oxygen	O_2 ~~N_2~~ (g)	0	
Nitrogen	N_2 (g)	0	
Carbon dioxide	CO_2 (g)	–393.52	
Water	H_2O (l)	–285.83	44.01
n-Octane	C_8H_{18} (g)	–208.45	41.46

Saturated Water, Pressure Table

Table C.2b Saturated Water, Pressure Table (Metric Units)

p, MPa	T, °C	Volume, m³/kg v_f	v_g	Energy, kJ/kg u_f	u_g	Enthalpy, kJ/kg h_f	h_{fg}	h_g	Entropy, kJ/(kg K) s_f	s_{fg}	s_g
0.000611	0.01	0.001000	206.1	0.0	2375.3	0.0	2501.3	2501.3	0.0000	9.1571	9.1571
0.0008	3.8	0.001000	159.7	15.8	2380.5	15.8	2492.5	2508.3	0.0575	9.0007	9.0582
0.001	7.0	0.001000	129.2	29.3	2385.0	29.3	2484.9	2514.2	0.1059	8.8706	8.9765
0.0012	9.7	0.001000	108.7	40.6	2388.7	40.6	2478.5	2519.1	0.1460	8.7639	8.9099
0.0014	12.0	0.001001	93.92	50.3	2391.9	50.3	2473.1	2523.4	0.1802	8.6736	8.8538
0.0016	14.0	0.001001	82.78	58.9	2394.7	58.9	2468.2	2527.1	0.2101	8.5952	8.8053
0.0018	15.8	0.001001	74.03	66.5	2397.2	66.5	2464.0	2530.5	0.2367	8.5259	8.7626
0.002	17.5	0.001001	67.00	73.5	2399.5	73.5	2460.0	2533.5	0.2606	8.4639	8.7245
0.003	24.1	0.001003	45.67	101.0	2408.5	101.0	2444.5	2545.5	0.3544	8.2240	8.5784
0.004	29.0	0.001004	34.80	121.4	2415.2	121.4	2433.0	2554.4	0.4225	8.0529	8.4754
0.006	36.2	0.001006	23.74	151.5	2424.9	151.5	2415.9	2567.4	0.5208	7.8104	8.3312
0.008	41.5	0.001008	18.10	173.9	2432.1	173.9	2403.1	2577.0	0.5924	7.6371	8.2295
0.01	45.8	0.001010	14.67	191.8	2437.9	191.8	2392.8	2584.6	0.6491	7.5019	8.1510
0.012	49.4	0.001012	12.36	206.9	2442.7	206.9	2384.1	2591.0	0.6961	7.3910	8.0871
0.014	52.6	0.001013	10.69	220.0	2446.9	220.0	2376.6	2596.6	0.7365	7.2968	8.0333
0.016	55.3	0.001015	9.433	231.5	2450.5	231.6	2369.9	2601.4	0.7719	7.2149	7.9868
0.018	57.8	0.001016	8.445	241.9	2453.8	241.9	2363.9	2605.8	0.8034	7.1425	7.9459
0.02	60.1	0.001017	7.649	251.4	2456.7	251.4	2358.3	2609.7	0.8319	7.0774	7.9093
0.03	69.1	0.001022	5.229	289.2	2468.4	289.2	2336.1	2625.3	0.9439	6.8256	7.7695
0.04	75.9	0.001026	3.993	317.5	2477.0	317.6	2319.1	2636.7	1.0260	6.6449	7.6709
0.06	85.9	0.001033	2.732	359.8	2489.6	359.8	2293.7	2653.5	1.1455	6.3873	7.5328
0.08	93.5	0.001039	2.087	391.6	2498.8	391.6	2274.1	2665.7	1.2331	6.2023	7.4354
0.1	99.6	0.001043	1.694	417.3	2506.1	417.4	2258.1	2675.5	1.3029	6.0573	7.3602
0.12	104.8	0.001047	1.428	439.2	2512.1	439.3	2244.2	2683.5	1.3613	5.9378	7.2989
0.14	109.3	0.001051	1.237	458.2	2517.3	458.4	2232.0	2690.4	1.4112	5.8360	7.2472
0.16	113.3	0.001054	1.091	475.2	2521.8	475.3	2221.2	2696.5	1.4553	5.7472	7.2025
0.18	116.9	0.001058	0.9775	490.5	2525.9	490.7	2211.1	2701.8	1.4948	5.6683	7.1631

p, MPa	T, °C	Volume, m³/kg v_f	v_g	Energy, kJ/kg u_f	u_g	Enthalpy, kJ/kg h_f	h_{fg}	h_g	Entropy, kJ/(kg K) s_f	s_{fg}	s_g
0.2	120.2	0.001061	0.8857	504.5	2529.5	504.7	2201.9	2706.6	1.5305	5.5975	7.1280
0.3	133.5	0.001073	0.6058	561.1	2543.6	561.5	2163.8	2725.3	1.6722	5.3205	6.9927
0.4	143.6	0.001084	0.4625	604.3	2553.6	604.7	2133.8	2738.5	1.7770	5.1197	6.8967
0.6	158.9	0.001101	0.3157	669.9	2567.4	670.6	2086.2	2756.8	1.9318	4.8293	6.7609
0.8	170.4	0.001115	0.2404	720.2	2576.8	721.1	2048.0	2769.1	2.0466	4.6170	6.6636
1	179.9	0.001127	0.1944	761.7	2583.6	762.8	2015.3	2778.1	2.1391	4.4482	6.5873
1.2	188.0	0.001139	0.1633	797.3	2588.8	798.6	1986.2	2784.8	2.2170	4.3072	6.5242
1.4	195.1	0.001149	0.1408	828.7	2592.8	830.3	1959.7	2790.0	2.2847	4.1854	6.4701
1.6	201.4	0.001159	0.1238	856.9	2596.0	858.8	1935.2	2794.0	2.3446	4.0780	6.4226
1.8	207.2	0.001168	0.1104	882.7	2598.4	884.6	1912.3	2797.1	2.3986	3.9816	6.3802
2	212.4	0.001177	0.09963	906.4	2600.3	908.8	1890.7	2799.5	2.4478	3.8939	6.3417
3	233.9	0.001216	0.06668	1004.8	2604.1	1008.4	1795.7	2804.1	2.6462	3.5416	6.1878
4	250.4	0.001252	0.04978	1082.3	2602.3	1087.3	1714.1	2801.4	2.7970	3.2739	6.0709
6	275.6	0.001319	0.03244	1205.4	2589.7	1213.3	1571.0	2784.3	3.0273	2.8627	5.8900
8	295.1	0.001384	0.02352	1305.6	2569.8	1316.6	1441.4	2758.0	3.2075	2.5365	5.7440
9	303.4	0.001418	0.02048	1350.5	2557.8	1363.3	1378.8	2742.1	3.2865	2.3916	5.6781
10	311.1	0.001452	0.01803	1393.0	2544.4	1407.6	1317.1	2724.7	3.3603	2.2546	5.6149
12	324.8	0.001527	0.01426	1472.9	2513.7	1491.3	1193.6	2684.9	3.4970	1.9963	5.4933
14	336.8	0.001611	0.01149	1548.6	2476.8	1571.1	1066.5	2637.6	3.6240	1.7486	5.3726
16	347.4	0.001711	0.009307	1622.7	2431.8	1650.0	930.7	2580.7	3.7468	1.4996	5.2464
18	357.1	0.001840	0.007491	1698.9	2374.4	1732.0	777.2	2509.2	3.8722	1.2332	5.1054
20	365.8	0.002036	0.005836	1785.6	2293.2	1826.3	583.7	2410.0	4.0146	0.9135	4.9281
22.088	374.136	0.003155	0.003155	2029.6	2029.6	2099.3	0.0	2099.3	4.4305	0.0000	4.4305

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Saturated Water, Temperature Table

Table C.1b Saturated Water, Temperature Table (Metric Units)

		Volume, m³/kg		Energy, kJ/kg		Enthalpy, kJ/kg			Entropy, kJ/(kg·K)		
T, °C	p, MPa	v_f	v_g	u_f	u_g	h_f	h_{fg}	h_g	s_f	s_{fg}	s_g
0.010	0.0006113	0.001000	206.1	0.0	2375.3	0.0	2501.3	2501.3	0.0000	9.1571	9.1571
2	0.0007056	0.001000	179.9	8.4	2378.1	8.4	2496.6	2505.0	0.0305	9.0738	9.1043
5	0.0008721	0.001000	147.1	21.0	2382.2	21.0	2489.5	2510.5	0.0761	8.9505	9.0266
10	0.001228	0.001000	106.4	42.0	2389.2	42.0	2477.7	2519.7	0.1510	8.7498	8.9008
15	0.001705	0.001001	77.93	63.0	2396.0	63.0	2465.9	2528.9	0.2244	8.5569	8.7822
20	0.002338	0.001002	57.79	83.9	2402.9	83.9	2454.2	2538.1	0.2965	8.3715	8.6680
25	0.003169	0.001003	43.36	104.9	2409.8	104.9	2442.3	2547.2	0.3672	8.1916	8.5588
30	0.004246	0.001004	32.90	125.8	2416.6	125.8	2430.4	2556.2	0.4367	8.0174	8.4541
35	0.005628	0.001006	25.22	146.7	2423.4	146.7	2418.6	2565.3	0.5051	7.8488	8.3539
40	0.007385	0.001008	19.52	167.5	2430.1	167.5	2406.8	2574.3	0.5723	7.6855	8.2578
45	0.009595	0.001010	15.26	188.4	2436.8	188.4	2394.8	2583.2	0.6385	7.5271	8.1656
50	0.01235	0.001012	12.03	209.3	2443.5	209.3	2382.8	2592.1	0.7036	7.3725	8.0771
55	0.01576	0.001015	9.569	230.2	2450.1	230.2	2370.7	2600.9	0.7678	7.2243	7.9921
60	0.01994	0.001017	7.671	251.1	2456.6	251.1	2358.5	2609.6	0.8310	7.0794	7.9104
65	0.02503	0.001020	6.197	272.0	2463.1	272.0	2346.2	2618.2	0.8934	6.9384	7.8318
70	0.03119	0.001023	5.042	292.9	2469.5	293.0	2333.8	2626.8	0.9549	6.8012	7.7561
75	0.03858	0.001026	4.131	313.9	2475.9	313.9	2321.4	2635.3	1.0155	6.6678	7.6833
80	0.04739	0.001029	3.407	334.8	2482.2	334.9	2308.8	2643.7	1.0754	6.5376	7.6130
85	0.05783	0.001032	2.828	355.8	2488.4	355.9	2296.0	2651.9	1.1344	6.4109	7.5453
90	0.07013	0.001036	2.361	376.8	2494.5	376.9	2283.2	2660.1	1.1927	6.2872	7.4799
95	0.08455	0.001040	1.982	397.9	2500.6	397.9	2270.2	2668.1	1.2503	6.1664	7.4167
100	0.1013	0.001044	1.673	418.9	2506.5	419.0	2257.0	2676.0	1.3071	6.0486	7.3557
110	0.1433	0.001052	1.210	461.1	2518.1	461.3	2230.2	2691.5	1.4188	5.8207	7.2395
120	0.1985	0.001060	0.8919	503.5	2529.2	503.7	2202.6	2706.3	1.5280	5.6024	7.1304
130	0.2701	0.001070	0.6685	546.0	2539.9	546.3	2174.2	2720.5	1.6348	5.3929	7.0277
140	0.3613	0.001080	0.5089	588.7	2550.0	589.1	2144.8	2733.9	1.7395	5.1912	6.9307
150	0.4758	0.001090	0.3928	631.7	2559.5	632.2	2114.2	2746.4	1.8422	4.9965	6.8387

		Volume, m³/kg		Energy, kJ/kg		Enthalpy, kJ/kg			Entropy, kJ/(kg·K)		
T, °C	p, MPa	v_f	v_g	u_f	u_g	h_f	h_{fg}	h_g	s_f	s_{fg}	s_g
160	0.6178	0.001102	0.3071	674.9	2568.4	675.5	2082.6	2758.1	1.9431	4.6079	6.7510
170	0.7916	0.001114	0.2428	718.3	2576.5	719.2	2049.5	2768.7	2.0423	4.6249	6.6672
180	1.002	0.001127	0.1941	762.1	2583.7	763.2	2015.0	2778.2	2.1400	4.4466	6.5866
190	1.254	0.001141	0.1565	806.2	2590.0	807.5	1978.8	2786.4	2.2363	4.2724	6.5087
200	1.554	0.001156	0.1274	850.6	2595.3	852.4	1940.8	2793.2	2.3310	4.1018	6.4323
210	1.906	0.001173	0.1044	895.5	2599.4	897.7	1900.8	2798.5	2.4253	3.9340	6.3593
220	2.318	0.001190	0.08620	940.9	2602.4	943.6	1858.5	2802.1	2.5183	3.7686	6.2869
230	2.795	0.001209	0.07159	986.7	2603.9	990.1	1813.9	2804.0	2.6105	3.6050	6.2155
240	3.344	0.001229	0.05977	1033.2	2604.0	1037.3	1766.5	2803.8	2.7021	3.4425	6.1446
250	3.973	0.001251	0.05013	1080.4	2602.4	1085.3	1716.2	2801.5	2.7933	3.2805	6.0738
260	4.688	0.001276	0.04221	1128.4	2599.0	1134.4	1662.5	2796.9	2.8844	3.1184	6.0028
270	5.498	0.001302	0.03565	1177.3	2593.7	1184.5	1605.2	2789.7	2.9757	2.9553	5.9310
280	6.411	0.001332	0.03017	1227.4	2586.1	1236.0	1543.6	2779.6	3.0674	2.7905	5.8579
290	7.436	0.001366	0.02557	1278.9	2576.0	1289.0	1477.2	2766.2	3.1600	2.6230	5.7830
300	8.580	0.001404	0.02168	1332.0	2563.0	1344.0	1405.0	2749.0	3.2540	2.4513	5.7053
310	9.856	0.001447	0.01835	1387.0	2546.4	1401.3	1326.0	2727.3	3.3500	2.2739	5.6239
320	11.27	0.001499	0.01549	1444.6	2525.5	1461.4	1238.7	2700.1	3.4487	2.0883	5.5370
330	12.84	0.001561	0.01300	1505.2	2499.0	1525.3	1140.6	2665.9	3.5514	1.8911	5.4425
340	14.59	0.001638	0.01080	1570.3	2464.6	1594.2	1027.9	2622.1	3.6601	1.6765	5.3366
350	16.51	0.001740	0.008815	1641.8	2418.5	1670.6	893.4	2564.0	3.7784	1.4338	5.2122
360	18.65	0.001892	0.006947	1725.2	2351.6	1760.5	720.7	2481.2	3.9154	1.1382	5.0536
370	21.03	0.002213	0.004931	1844.0	2229.0	1890.5	442.2	2332.7	4.1114	0.6876	4.7990
374.136	22.088	0.003155	0.003155	2029.6	2029.6	2099.3	0.0	2099.3	4.4305	0.0000	4.4305

Table C.3b Superheated Water Vapor (Metric Units) *continued*

P, MPa (T_{sat}, °C)		Temperature, °C 250	300	350	400	450	500	550	600	650	700	750	800	900
2 (212.4)	v, m³/kg	0.1114	0.1255	0.1386	0.1512	0.1635	0.1757	0.1877	0.1996	0.2114	0.2232	0.2350	0.2467	0.2700
	u, kJ/kg	2679.6	2772.6	2859.8	2945.2	3030.4	3116.2	3203.0	3290.9	3380.2	3471.0	3563.2	3057.0	3849.3
	h, kJ/kg	2902.5	3023.5	3137.0	3247.6	3357.5	3467.6	3578.3	3690.1	3803.1	3917.5	4033.2	4150.4	4389.4
	s, kJ/(kg·K)	6.5461	6.7672	6.9571	7.1279	7.2853	7.4325	7.5713	7.7032	7.8290	7.9496	8.0656	8.1774	8.3903
3 (233.9)	v, m³/kg	0.07058	0.08114	0.09053	0.09936	0.1079	0.1162	0.1244	0.1324	0.1404	0.1484	0.1583	0.1641	0.1798
	u, kJ/kg	2644.0	2750.0	2843.7	2932.7	3020.4	3107.9	3196.0	3285.0	3376.2	3468.8	3559.4	3653.6	3846.5
	h, kJ/kg	2855.8	2993.5	3115.3	3230.8	3344.0	3456.5	3569.1	3682.3	3796.5	3911.7	4028.2	4146.0	4385.9
	s, kJ/(kg·K)	6.2880	6.5398	6.7436	6.9220	7.0842	7.2346	7.3757	7.5093	7.6364	7.7580	7.8747	7.987	8.2008
4 (250.4)	v, m³/kg	–	0.05884	0.06645	0.07341	0.08003	0.08643	0.09269	0.09885	0.1049	0.1109	0.1169	0.1229	0.1347
	u, kJ/kg	–	2725.3	2826.6	2919.0	3010.1	3099.5	3189.0	3279.1	3370.1	3462.1	3555.5	3650.1	3843.6
	h, kJ/kg	–	2960.7	3092.4	3213.5	3330.2	3445.2	3559.7	3674.4	3789.8	3905.9	4023.2	4141.6	4382.3
	s, kJ/(kg·K)	–	6.3622	6.5828	6.7698	6.9371	7.0908	7.2343	7.3696	7.4981	7.6206	7.7381	7.8511	8.0655
6 (275.6)	v, m³/kg	–	0.03616	0.04223	0.04730	0.05214	0.05665	0.06101	0.06525	0.06942	0.07352	0.07758	0.08160	0.08958
	u, kJ/kg	–	2667.2	2789.6	2892.9	2988.9	3082.2	3174.6	3266.9	3359.6	3453.2	3547.6	3643.1	3837.8
	h, kJ/kg	–	2884.2	3043.0	3177.2	3301.8	3422.1	3540.6	3658.4	3776.2	3894.3	4013.1	4132.7	4375.3
	s, kJ/(kg·K)	–	6.0682	6.3342	6.5415	6.7201	6.8811	7.0296	7.1685	7.2996	7.4242	7.5433	7.6575	7.8736
8 (295.1)	v, m³/kg	–	0.02426	0.02995	0.03432	0.03817	0.04175	0.04516	0.04845	0.05166	0.05481	0.05791	0.06097	0.06702
	u, kJ/kg	–	2590.9	2747.7	2863.8	2966.7	3064.3	3159.8	3254.4	3349.0	3444.0	3539.6	3636.1	3832.1
	h, kJ/kg	–	2785.0	2987.3	3138.3	3272.0	3398.3	3521.0	3642.0	3762.3	3882.5	4002.9	4123.8	4368.3
	s, kJ/(kg·K)	–	5.7914	6.1309	6.3642	6.5559	6.7248	6.8786	7.0214	7.1553	7.2821	7.4027	7.5182	7.7359
10 (311.1)	v, m³/kg	–	–	0.02242	0.02641	0.02975	0.03279	0.03564	0.03837	0.04101	0.04358	0.04611	0.04859	0.05349
	u, kJ/kg	–	–	2699.2	2832.4	2943.3	3045.8	3144.5	3241.7	3338.2	3434.7	3531.5	3629.0	3826.3
	h, kJ/kg	–	–	2923.4	3096.5	3240.8	3373.6	3500.9	3625.3	3748.3	3870.5	3992.6	4114.8	4361.2
	s, kJ/(kg·K)	–	–	5.9451	6.212	6.4197	6.5974	6.7569	6.9037	7.0406	7.1696	7.2919	7.4086	7.6280
12 (324.8)	v, m³/kg	–	–	0.01721	0.02108	0.02412	0.02680	0.02929	0.03164	0.03390	0.03610	0.03824	0.04034	0.04447
	u, kJ/kg	–	–	2641.1	2798.3	2918.8	3026.6	3128.9	3228.7	3327.2	3425.3	3523.4	3621.8	3820.6
	h, kJ/kg	–	–	2847.6	3051.2	3208.2	3348.2	3480.3	3608.3	3734.0	3858.4	3982.3	4105.9	4354.2
	s, kJ/(kg·K)	–	–	5.7604	6.0754	6.3006	6.4879	6.6535	6.8045	6.9445	7.0757	7.1998	7.3178	7.5390

P, MPa (T_{sat}, °C)		Temperature, °C 400	450	500	550	600	650	700	750	800	850	900	950	1000
15 (342.2)	v, m³/kg	0.01565	0.01845	0.02080	0.02293	0.02491	0.02680	0.02861	0.03037	0.03210	0.03379	0.03546	0.03711	0.03875
	u, kJ/kg	2740.7	2879.5	2996.5	3104.7	3208.6	3310.4	3410.9	3511.0	3611.0	3711.2	3811.9	3913.2	4015.4
	h, kJ/kg	2975.4	3156.2	3308.5	3448.6	3582.3	3712.3	3840.1	3966.6	4092.4	4218.0	4343.8	4469.9	4596.6
	s, kJ/(kg·K)	5.8819	6.1412	6.3451	6.5207	6.6784	6.8232	6.9580	7.0848	7.2048	7.3192	7.4288	7.5340	7.6356
20 (365.8)	v, m³/kg	0.00994	0.01270	0.01477	0.01656	0.01818	0.01969	0.02113	0.02251	0.02385	0.02516	0.02645	0.02771	0.02897
	u, kJ/kg	2619.2	2806.2	2942.8	3062.8	3174.0	3281.5	3386.5	3490.6	3592.7	3695.1	3797.4	3900.0	4003.1
	h, kJ/kg	2818.1	3060.1	3238.2	3393.4	3537.6	3675.3	3809.1	3940.8	4069.8	4196.3	4326.4	4454.8	4582.5
	s, kJ/(kg·K)	5.5648	5.9025	6.1409	6.3356	6.5056	6.6591	6.8002	6.9317	7.0553	7.1723	7.2839	7.3907	7.4933
22.088 (374.136)	v, m³/kg	0.00818	0.01104	0.01305	0.01475	0.01627	0.01768	0.01901	0.02029	0.02152	0.02272	0.02389	0.02506	0.02619
	u, kJ/kg	2552.9	2772.1	2919.0	3043.9	3159.1	3269.1	3376.1	3481.1	3585.0	3688.3	3791.4	3894.5	3998.0
	h, kJ/kg	2733.7	3015.9	3207.2	2369.6	3518.4	3659.6	3796.0	3929.2	4060.3	4190.1	4319.1	4447.9	4576.6
	s, kJ/(kg·K)	5.4013	5.8072	6.0634	6.2670	6.4426	6.5998	6.7437	6.8772	7.0024	7.1206	7.2330	7.3404	7.4436
30	v, m³/kg	0.00279	0.00674	0.00868	0.01017	0.01145	0.01260	0.01366	0.01466	0.01562	0.01655	0.01745	0.01833	0.01920
	u, kJ/kg	2067.3	2619.3	2820.7	2970.3	3100.5	3221.0	3335.8	3447.0	3555.6	3662.6	3768.5	3873.8	3978.8
	h, kJ/kg	2151.0	2821.4	3081.0	3275.4	3443.9	3598.9	3745.7	3886.9	4024.3	4159.0	4291.9	4423.6	4554.7
	s, kJ/(kg·K)	4.4736	5.4432	5.7912	6.0350	6.2339	6.4066	6.5614	6.7030	6.8341	6.9568	7.0726	7.1825	7.2875
40	v, m³/kg	0.00191	0.00369	0.00562	0.00698	0.00809	0.00906	0.00994	0.01076	0.01152	0.01226	0.01296	0.01365	0.01432
	u, kJ/kg	1854.5	2365.1	2678.4	2869.7	3022.6	3158.0	3283.6	3402.9	3517.9	3629.8	3739.4	3847.5	3954.6
	h, kJ/kg	1930.8	2512.8	2903.3	3149.1	3346.4	3520.6	3681.3	3833.1	3978.6	4120.0	4257.9	4393.6	4527.6
	s, kJ/(kg·K)	4.1143	4.9467	5.4707	5.7793	6.0122	6.2063	6.3759	6.5281	6.6671	6.7957	6.9158	7.0291	7.1365
60	v, m³/kg	0.00163	0.00208	0.00296	0.00396	0.00483	0.00560	0.00627	0.00689	0.00748	0.00800	0.00851	0.00900	0.00948
	u, kJ/kg	1745.3	2053.9	2380.5	2658.5	2861.1	3028.8	3177.2	3310.6	3441.6	3562.6	3681.0	3795.0	3906.4
	h, kJ/kg	1843.4	2179.0	2567.9	2896.2	3151.2	3364.5	3553.6	3728.8	3889.1	4043.3	4191.5	4335.0	4476.2
	s, kJ/(kg·K)	3.9325	4.4128	4.9329	5.3449	5.6460	5.8838	6.0832	6.2569	6.4118	6.5523	6.6814	6.8012	6.9135
80	v, m³/kg	0.00152	0.00177	0.00219	0.00276	0.00339	0.00398	0.00452	0.00502	0.00548	0.00591	0.00632	0.00671	0.00709
	u, kJ/kg	1687.0	1944.9	2218.9	2483.9	2711.8	2904.7	3070.2	3225.3	3365.7	3497.3	3622.3	3742.1	3857.8
	h, kJ/kg	1808.3	2086.9	2393.9	2704.9	2982.7	3222.8	3434.7	3626.6	3803.8	3970.1	4127.9	4279.1	4425.2
	s, kJ/(kg·K)	3.8338	4.2328	4.8432	5.0331	5.3609	5.6284	5.8521	6.0446	6.2137	6.3652	6.5020	6.6289	6.7459

Superheated Water Vapour

Table C.3b Superheated Water Vapor (Metric Units)

p, MPa (T_{sat}, °C)		Temperature, °C												
		50	100	150	200	250	300	350	400	500	600	700	800	900
0.002 (17.5)	v, m³/kg	74.52	86.08	97.63	109.2	120.7	132.3	143.8	155.3	178.4	201.5	224.6	247.6	270.7
	u, kJ/kg	2445.2	2516.3	2588.3	2661.6	2738.2	2812.2	2889.8	2969.0	3132.3	3302.5	3479.7	3663.9	3855.1
	h, kJ/kg	2594.3	2688.4	2783.6	2879.9	2977.6	3078.7	3177.4	3279.6	3489.1	3705.5	3928.8	4159.1	4396.5
	s, kJ/(kg·K)	8.9227	9.1936	9.4328	9.6479	9.8442	10.0251	10.1935	10.3513	10.6414	10.9044	11.1465	11.3718	11.5832
0.005 (32.9)	v, m³/kg	29.78	34.42	39.04	43.66	48.28	52.90	57.51	62.13	71.36	80.59	89.82	99.05	108.3
	u, kJ/kg	2444.7	2516.0	2588.1	2661.5	2736.1	2812.2	2889.8	2968.9	3132.3	3302.5	3479.6	3663.9	3855.0
	h, kJ/kg	2593.6	2688.1	2783.3	2879.8	2977.6	3076.6	3177.3	3279.8	3489.1	3705.4	3928.8	4159.1	4396.5
	s, kJ/(kg·K)	8.4982	8.7699	9.0095	9.2248	9.4212	9.6022	9.7706	9.9284	10.2185	10.4816	10.7236	10.9489	11.1603
0.01 (45.8)	v, m³/kg	14.87	17.20	19.51	21.83	24.14	26.45	28.75	31.06	35.68	40.29	44.91	49.53	54.14
	u, kJ/kg	2443.9	2515.5	2587.9	2661.3	2736.0	2812.1	2889.7	2968.9	3132.3	3302.5	3479.6	3663.8	3855.0
	h, kJ/kg	2592.6	2687.5	2783.0	2879.5	2977.3	3076.5	3177.2	3279.5	3489.0	3705.4	3928.7	4159.1	4396.4
	s, kJ/(kg·K)	8.1757	8.4487	8.6890	8.9046	9.1010	9.2821	9.4506	9.6084	9.8985	10.1616	10.4037	10.6290	10.8404
0.02 (60.1)	v, m³/kg	–	8.585	9.748	10.91	12.06	13.22	14.37	15.53	17.84	20.15	22.45	24.76	27.07
	u, kJ/kg	–	2514.5	2587.3	2660.9	2735.7	2811.9	2889.5	2968.8	3132.2	3302.4	3479.5	3663.8	3855.0
	h, kJ/kg	–	2686.2	2782.3	2879.1	2977.0	3076.3	3177.0	3279.4	3488.9	3705.3	3928.7	4159.1	4396.4
	s, kJ/(kg·K)	–	8.1263	8.3678	8.5839	8.7807	8.9619	9.1304	9.2884	9.5785	9.8417	10.0838	10.3091	10.5205
0.05 (81.3)	v, m³/kg	–	3.418	3.889	4.356	4.820	5.284	5.747	6.209	7.134	8.057	8.981	9.904	10.83
	u, kJ/kg	–	2511.6	2585.6	2659.8	2735.0	2811.3	2889.1	2968.4	3131.9	3302.2	3479.5	3003.7	3854.9
	h, kJ/kg	–	2682.5	2780.1	2877.6	2976.0	3075.5	3176.4	3278.9	3488.6	3705.1	3928.5	4158.9	4396.3
	s, kJ/(kg·K)	–	7.6955	7.9409	8.1588	8.3564	8.5380	8.7069	8.8650	9.1554	9.4186	9.6608	9.8861	10.0975
0.07 (89.9)	v, m³/kg	–	2.434	2.773	3.108	3.441	3.772	4.103	4.434	5.095	5.755	6.415	7.074	7.734
	u, kJ/kg	–	2509.6	2584.6	2659.1	2734.5	2811.0	2888.8	2968.2	3131.8	3302.1	3479.4	3663.6	3854.9
	h, kJ/kg	–	2680.0	2778.6	2876.7	2975.3	3075.0	3176.1	3278.6	3488.4	3704.9	3928.4	4158.8	4396.2
	s, kJ/(kg·K)	–	7.5349	7.7829	8.0020	8.2001	8.3821	8.5511	8.7094	8.9999	9.2632	9.5054	9.7307	9.9422
0.1 (99.6)	v, m³/kg	–	1.696	1.936	2.172	2.406	2.639	2.871	3.103	3.565	4.028	4.490	4.952	5.414
	u, kJ/kg	–	2506.6	2582.7	2658.0	2733.7	2810.4	2888.4	2967.8	3131.5	3301.9	3479.2	3063.5	3854.8
	h, kJ/kg	–	2676.2	2776.4	2875.3	2974.3	3074.3	3175.5	3278.1	3488.1	3704.7	3928.2	4158.7	4390.1
	s, kJ/(kg·K)	–	7.3622	7.6142	7.8351	8.0341	8.2165	8.3858	8.5442	8.8350	9.0984	9.3408	9.5660	9.7775

p, MPa (T_{sat}, °C)		Temperature, °C												
		150	200	250	300	350	400	450	500	550	600	700	800	900
0.15 (111.4)	v, m³/kg	1.285	1.444	1.601	1.757	1.912	2.067	2.222	2.376	2.530	2.685	2.993	3.301	3.609
	u, kJ/kg	2579.8	2656.2	2732.5	2809.5	2887.7	2967.3	3048.4	3131.1	3215.6	3301.8	3479.0	3663.4	3854.6
	h, kJ/kg	2772.6	2872.9	2972.7	3073.0	3174.5	3277.3	3381.7	3487.6	3595.1	3704.3	3927.9	4158.5	4395.9
	s, kJ/(kg·K)	7.4201	7.6441	7.8446	8.0278	8.1975	8.3562	8.5057	8.6473	8.7821	8.9109	9.1533	9.3787	9.5903
0.2 (120.2)	v, m³/kg	0.9596	1.080	1.199	1.316	1.433	1.549	1.665	1.781	1.897	2.013	2.244	2.475	2.706
	u, kJ/kg	2576.9	2654.4	2731.2	2808.6	2886.9	2966.7	3047.9	3130.7	3215.2	3301.4	3478.8	3662.2	3854.6
	h, kJ/kg	2768.8	2870.5	2971.0	3071.8	3173.5	3276.5	3381.0	3487.0	3594.7	3704.0	3927.7	4158.3	4395.8
	s, kJ/(kg·K)	7.2803	7.5074	7.7094	7.8934	8.0636	8.2226	8.3723	8.5140	8.6489	8.7778	9.0203	9.2458	9.4574
0.4 (143.6)	v, m³/kg	0.4708	0.5342	0.5951	0.6548	0.7139	0.7726	0.8311	0.8893	0.9475	1.006	1.121	1.237	1.353
	u, kJ/kg	2564.5	2646.8	2726.1	2804.8	2884.0	2964.4	3046.0	3129.2	3213.9	3300.2	3477.9	3662.5	3853.9
	h, kJ/kg	2752.8	2860.5	2964.2	3066.7	3169.6	3273.4	3378.4	3484.9	3592.9	3702.4	3926.5	4157.4	4395.1
	s, kJ/(kg·K)	6.9307	7.1714	7.3797	7.5670	7.7390	7.8992	8.0497	8.1921	8.3274	8.4566	8.6995	8.9253	9.1370
0.6 (158.9)	v, m³/kg	–	0.3520	0.3938	0.4344	0.4742	0.5137	0.5529	0.5920	0.6309	0.6697	0.7472	0.8245	0.9017
	u, kJ/kg	–	2638.9	2720.9	2801.0	2881.1	2962.0	3044.1	3127.6	3212.5	3299.1	3477.1	3661.8	3853.3
	h, kJ/kg	–	2850.1	2957.2	3061.6	3165.7	3270.3	3375.9	3482.7	3591.1	3700.9	3925.4	4155.5	4394.4
	s, kJ/(kg·K)	–	6.9673	7.1824	7.3732	7.5472	7.7080	7.8600	8.0028	8.1368	8.2682	8.5115	8.7375	8.9492
0.8 (170.4)	v, m³/kg	–	0.2608	0.2931	0.3241	0.3544	0.3843	0.4139	0.4433	0.4726	0.5018	0.5601	0.6181	0.6761
	u, kJ/kg	–	2630.6	2715.5	2797.1	2878.2	2959.7	3042.2	3125.9	3211.2	3297.9	3476.2	3661.1	3852.8
	h, kJ/kg	–	2839.2	2950.0	3056.4	3161.7	3267.1	3373.3	3480.6	3589.3	3699.4	3924.3	4155.7	4393.6
	s, kJ/(kg·K)	–	6.8157	7.0392	7.2336	7.4097	7.5723	7.7245	7.8680	8.0042	8.1341	8.3779	8.6041	8.8161
1 (179.9)	v, m³/kg	–	0.2060	0.2327	0.2579	0.2825	0.3066	0.3304	0.3541	0.3776	0.4011	0.4478	0.4943	0.5407
	u, kJ/kg	–	2621.9	2709.9	2793.2	2875.2	2957.3	3040.2	3124.3	3209.8	3296.8	3475.4	3660.5	3852.2
	h, kJ/kg	–	2827.9	2942.6	3051.2	3157.7	3263.9	3370.7	3478.4	3587.6	3697.9	3923.1	4154.8	4392.9
	s, kJ/(kg·K)	–	6.6948	6.9255	7.1237	7.3019	7.4658	7.6188	7.7630	7.8996	8.0298	8.2740	8.5005	8.7127
1.5 (198.3)	v, m³/kg	–	0.1325	0.1520	0.1697	0.1866	0.2030	0.2192	0.2352	0.2510	0.2658	0.2981	0.3292	0.3603
	u, kJ/kg	–	2598.1	2695.3	2783.1	2867.6	2951.3	3035.3	3120.3	3206.4	3293.9	3473.2	3658.7	3850.8
	h, kJ/kg	–	2796.8	2923.2	3037.6	3147.4	3255.8	3364.1	3473.0	3582.9	3694.0	3920.3	4152.8	4391.2
	s, kJ/(kg·K)	–	6.4554	6.7098	6.9187	7.1025	7.2697	7.4249	7.5706	7.7083	7.8393	8.0846	8.3118	8.5243

ENTHALPY - KJ PER KILOGRAM OF DRY AIR

(8)

Saturated R134a Vapour

Table C.7c Saturated Refrigerant-134a Temperature Table (Metric Units)

Temp. °C T	Press. MPa P_{sat}	Specific Volume m³/kg Sat. Liquid v_f	Sat. Vapor v_g	Internal Energy kJ/kg Sat. Liquid u_f	Sat. Vapor u_g	Sat. Liquid h_f	Enthalpy kJ/kg Evap. h_{fg}	Sat. Vapor h_g	Entropy kJ/(kg·K) Sat. Liquid s_f	Sat. Vapor s_g
−40	0.051 64	0.000 705 5	0.3569	−0.04	204.45	0.00	222.88	222.88	0.0000	0.9560
−36	0.063 32	0.000 711 3	0.2947	4.68	206.73	4.73	220.67	225.40	0.0201	0.9506
−32	0.077 04	0.000 717 2	0.2451	9.47	209.01	9.52	218.37	227.90	0.0401	0.9456
−28	0.093 05	0.000 723 3	0.2052	14.31	211.29	14.37	216.01	230.38	0.0600	0.9411
−26	0.101 99	0.000 726 5	0.1882	16.76	212.43	16.82	214.80	231.62	0.0699	0.9390
−24	0.111 60	0.000 729 6	0.1728	19.21	213.57	19.29	213.57	232.85	0.0798	0.9370
−22	0.121 92	0.000 732 8	0.1590	21.68	214.70	21.77	212.32	234.08	0.0897	0.9351
−20	0.132 99	0.000 736 1	0.1464	24.17	215.84	24.26	211.05	235.31	0.0996	0.9332
−18	0.144 83	0.000 739 5	0.1350	26.67	216.97	26.77	209.76	236.53	0.1094	0.9315
−16	0.157 48	0.000 742 6	0.1247	29.18	218.10	29.30	208.45	237.74	0.1192	0.9288
−12	0.185 40	0.000 749 8	0.1068	34.25	220.36	34.39	205.77	240.15	0.1388	0.9267
−8	0.217 04	0.000 756 9	0.0919	39.38	222.60	39.54	203.00	242.54	0.1583	0.9239
−4	0.252 74	0.000 764 4	0.0794	44.56	224.84	44.75	200.15	244.90	0.1777	0.9213
0	0.292 82	0.000 772 1	0.0689	49.79	227.06	50.02	197.21	247.23	0.1970	0.9190
4	0.337 65	0.000 780 1	0.0600	55.06	229.27	55.35	194.19	249.53	0.2162	0.9169
8	0.387 56	0.000 788 4	0.0525	60.43	231.46	60.73	191.07	251.80	0.2354	0.9150
12	0.442 94	0.000 797 4	0.0460	65.83	233.63	66.18	187.85	254.03	0.2548	0.9132
16	0.504 16	0.000 806 2	0.0405	71.29	235.78	71.69	184.52	256.22	0.2735	0.9116
20	0.571 60	0.000 815 7	0.0358	76.80	237.91	77.26	181.09	258.36	0.2924	0.9102
24	0.645 66	0.000 825 7	0.0317	82.37	240.01	82.90	177.55	260.45	0.3113	0.9089
26	0.685 30	0.000 830 9	0.0298	85.18	241.05	85.75	175.73	261.48	0.3208	0.9082
28	0.726 76	0.000 836 2	0.0281	88.00	242.08	88.61	173.89	262.50	0.3302	0.9076
30	0.770 06	0.000 841 7	0.0265	90.84	243.10	91.49	172.00	263.50	0.3396	0.9070
32	0.815 28	0.000 847 3	0.0250	93.70	244.12	94.39	170.09	264.48	0.3490	0.9064
34	0.862 47	0.000 853 0	0.0236	96.58	245.12	97.31	168.14	265.45	0.3584	0.9058
36	0.911 68	0.000 859 0	0.0223	99.47	246.11	100.25	166.15	266.40	0.3678	0.9053
38	0.962 98	0.000 865 1	0.0210	102.38	247.09	103.21	164.12	267.33	0.3772	0.9047
40	1.016 4	0.000 871 4	0.0199	105.30	248.06	106.19	162.05	268.24	0.3866	0.9041
42	1.072 0	0.000 878 0	0.0188	108.25	249.02	109.19	159.94	269.14	0.3960	0.9036
44	1.129 9	0.000 884 7	0.0177	111.22	249.96	112.22	157.79	270.01	0.4054	0.9030
48	1.252 6	0.000 898 9	0.0159	117.22	251.79	118.35	153.33	271.68	0.4243	0.9017
52	1.385 1	0.000 914 2	0.0142	123.31	253.55	124.58	148.66	273.24	0.4432	0.9004
56	1.527 8	0.000 930 6	0.0127	129.51	255.23	130.93	143.75	274.68	0.4622	0.8990
60	1.681 3	0.000 949 8	0.0114	135.82	256.81	137.42	138.57	275.99	0.4814	0.8973
70	2.116 2	0.001 002 7	0.0086	152.22	260.15	154.34	124.08	278.43	0.5302	0.8918
80	2.632 4	0.001 076 6	0.0064	169.88	262.14	172.71	106.41	279.12	0.5814	0.8827
90	3.243 5	0.001 194 9	0.0046	189.82	261.34	193.69	82.63	276.32	0.6360	0.8655
100	3.974 2	0.001 544 3	0.0027	218.60	248.49	224.74	34.40	259.13	0.7196	0.8117

Table C.7d Saturated Refrigerant-134a Pressure Table (Metric Units)

Press. MPa P	Temp. °C T_{sat}	Specific Volume m³/kg Sat. Liquid v_f	Sat. Vapor v_g	Internal Energy kJ/kg Sat. Liquid u_f	Sat. Vapor u_g	Sat. Liquid h_f	Enthalpy kJ/kg Evap. h_{fg}	Sat. Vapor h_g	Entropy kJ/(kg·K) Sat. Liquid s_f	Sat. Vapor s_g
0.06	−37.07	0.000 709 7	0.3100	3.41	206.12	3.46	221.27	224.72	0.0147	0.9520
0.08	−31.21	0.000 718 4	0.2366	10.41	209.46	10.47	217.92	228.39	0.0440	0.9447
0.10	−26.43	0.000 725 8	0.1917	16.22	212.18	16.29	215.06	231.35	0.0678	0.9395
0.12	−22.36	0.000 732 3	0.1614	21.23	214.50	21.32	212.54	233.86	0.0879	0.9354
0.14	−18.80	0.000 738 1	0.1395	25.66	216.50	25.77	210.27	236.04	0.1055	0.9322
0.16	−15.62	0.000 743 5	0.1229	29.66	218.32	29.78	208.18	237.97	0.1211	0.9295
0.18	−12.73	0.000 748 5	0.1098	33.31	219.94	33.45	206.26	239.71	0.1352	0.9273
0.20	−10.09	0.000 753 2	0.0993	36.69	221.43	36.84	204.46	241.30	0.1481	0.9253
0.24	−5.37	0.000 761 8	0.0834	42.77	224.07	42.95	201.14	244.09	0.1710	0.9222
0.28	−1.23	0.000 769 7	0.0719	48.18	226.38	48.39	198.13	246.52	0.1911	0.9197
0.32	2.48	0.000 777 0	0.0632	53.06	228.43	53.31	195.35	248.66	0.2089	0.9177
0.36	5.84	0.000 783 9	0.0564	57.54	230.28	57.82	192.76	250.58	0.2251	0.9160
0.4	8.93	0.000 790 4	0.0509	61.69	231.97	62.00	190.32	252.32	0.2399	0.9145
0.5	15.74	0.000 805 6	0.0409	70.93	235.64	71.33	184.74	256.07	0.2723	0.9117
0.6	21.58	0.000 819 6	0.0341	78.99	238.74	79.48	179.71	259.19	0.2999	0.9097
0.7	26.72	0.000 832 8	0.0292	86.19	241.42	86.78	175.07	261.85	0.3242	0.9080
0.8	31.33	0.000 845 4	0.0255	92.75	243.78	93.42	170.73	264.15	0.3459	0.9066
0.9	35.53	0.000 857 6	0.0226	98.79	245.88	99.56	166.62	266.18	0.3656	0.9054
1.0	39.39	0.000 869 5	0.0202	104.42	247.77	105.29	162.68	267.97	0.3838	0.9043
1.2	46.32	0.000 892 8	0.0166	114.69	251.03	115.76	155.23	270.99	0.4164	0.9023
1.4	52.43	0.000 915 9	0.0140	123.98	253.74	125.26	148.14	273.40	0.4453	0.9003
1.6	57.92	0.000 939 2	0.0121	132.52	256.00	134.02	141.31	275.33	0.4714	0.8982
1.8	62.91	0.000 963 1	0.0106	140.49	257.88	142.22	134.60	276.83	0.4954	0.8959
2.0	67.48	0.000 987 8	0.0093	148.02	259.41	149.99	127.95	277.94	0.5178	0.8934
2.5	77.59	0.001 056 2	0.0069	165.48	261.84	168.12	111.06	279.17	0.5687	0.8854
3.0	86.22	0.001 141 6	0.0053	181.88	262.16	185.30	92.71	278.01	0.6156	0.8735

Superheated R134a Vapour

Table C.8b Superheated Refrigerant-134a Vapor (Metric Units)

T °C	v m³/kg	u kJ/kg	h kJ/kg	s kJ/(kg K)	v m³/kg	u kJ/kg	h kJ/kg	s kJ/(kg K)
	$P = 0.06$ MPa ($T_{sat} = -37.07$°C)				$P = 0.10$ MPa ($T_{sat} = -26.43$°C)			
Sat.	0.31003	206.12	224.72	0.9520	0.19170	212.18	231.35	0.9395
−20	0.33536	217.86	237.98	1.0062	0.19770	216.77	236.54	0.9602
−10	0.34992	224.97	245.96	1.0371	0.20686	224.01	244.70	0.9918
0	0.36433	232.24	254.10	1.0675	0.21687	231.41	252.99	1.0227
10	0.37861	239.69	262.41	1.0973	0.22473	238.96	261.43	1.0531
20	0.39279	247.32	270.89	1.1267	0.23349	246.67	270.02	1.0829
30	0.40688	255.12	279.53	1.1557	0.24216	254.54	278.76	1.1122
40	0.42091	263.10	288.35	1.1844	0.25076	262.58	287.66	1.1411
50	0.43487	271.25	297.34	1.2126	0.25930	270.79	296.72	1.1696
60	0.44879	279.58	306.51	1.2405	0.26779	279.16	305.94	1.1977
70	0.46266	288.08	315.84	1.2681	0.27623	287.70	315.32	1.2254
80	0.47650	296.75	325.34	1.2954	0.28464	296.40	324.87	1.2528
90	0.49031	305.58	335.00	1.3224	0.29302	305.27	334.57	1.2799
	$P = 0.14$ MPa ($T_{sat} = -18.80$°C)				$P = 0.18$ MPa ($T_{sat} = -12.73$°C)			
Sat.	0.13945	216.52	236.04	0.9322	0.10983	219.94	239.71	0.9273
−10	0.14549	223.03	243.40	0.9606	0.11135	222.02	242.06	0.9362
0	0.15219	230.55	251.86	0.9922	0.11678	229.67	250.69	0.9684
10	0.15875	238.21	260.43	1.0230	0.12207	237.44	259.41	0.9998
20	0.16520	246.01	269.13	1.0532	0.12723	245.33	268.23	1.0304
30	0.17155	253.96	277.97	1.0828	0.13230	253.36	277.17	1.0604
40	0.17783	262.06	286.96	1.1120	0.13730	261.53	286.24	1.0898
50	0.18404	270.32	296.09	1.1407	0.14222	269.85	295.46	1.1187
60	0.19020	278.74	305.37	1.1690	0.14710	278.31	304.79	1.1472
70	0.19633	287.32	314.80	1.1969	0.15193	286.93	314.28	1.1753
80	0.20241	296.05	324.39	1.2244	0.15672	295.71	323.92	1.2030
90	0.20846	304.95	334.14	1.2516	0.16148	304.63	333.70	1.2303
100	0.21449	314.01	344.04	1.2785	0.16622	313.72	343.63	1.2573
	$P = 0.20$ MPa ($T_{sat} = -10.09$°C)				$P = 0.24$ MPa ($T_{sat} = -5.37$°C)			
Sat.	0.09933	221.43	241.30	0.9253	0.08343	224.07	244.09	0.9222
−10	0.09938	221.50	241.38	0.9256	—	—	—	—
0	0.10438	229.23	250.10	0.9582	0.08574	228.31	248.89	0.9399
10	0.10922	237.05	258.89	0.9898	0.08993	236.26	257.84	0.9721
20	0.11394	244.99	267.78	1.0206	0.09399	244.30	266.85	1.0034
30	0.11856	253.05	276.77	1.0508	0.09794	252.45	275.95	1.0339
40	0.12311	261.26	285.88	1.0804	0.10181	260.72	285.16	1.0637
50	0.12758	269.61	295.12	1.1094	0.10562	269.12	294.47	1.0930
60	0.13201	278.10	304.50	1.1380	0.10937	277.67	303.91	1.1218
70	0.13639	286.74	314.02	1.1681	0.11307	286.35	313.49	1.1501
80	0.14073	295.53	323.68	1.1939	0.11674	295.18	323.19	1.1780
90	0.14504	304.47	333.48	1.2212	0.12037	304.15	333.04	1.2055
100	0.14932	313.57	343.43	1.2483	0.12398	313.27	343.03	1.2326
	$P = 0.28$ MPa ($T_{sat} = -1.23$°C)				$P = 0.32$ MPa ($T_{sat} = 2.48$°C)			
Sat.	0.07193	226.38	246.52	0.9187	0.06322	228.43	248.66	0.9177
0	0.07240	227.37	247.64	0.9238	—	—	—	—
10	0.07613	235.44	256.76	0.9566	0.06576	234.61	255.65	0.9427
20	0.07972	243.59	265.91	0.9883	0.06901	242.87	264.95	0.9749
30	0.08320	251.83	275.12	1.0192	0.07214	251.19	274.28	1.0062

Table C.8b Superheated Refrigerant-134a Vapor (Metric Units) *continued*

T °C	v m³/kg	u kJ/kg	h kJ/kg	s kJ/(kg·K)	v m³/kg	u kJ/kg	h kJ/kg	s kJ/(kg·K)
90	0.03393	299.37	326.52	1.0940	0.02980	298.46	325.28	1.0819
100	0.03519	308.93	337.08	1.1227	0.03095	308.11	335.96	1.1109
110	0.03642	318.57	347.71	1.1508	0.03207	317.82	346.68	1.1392
120	0.03762	328.31	358.40	1.1784	0.03316	327.62	357.47	1.1670
130	0.03881	338.14	369.19	1.2055	0.03423	337.52	368.33	1.1943
140	0.03997	348.09	380.07	1.2321	0.03529	347.51	379.27	1.2211
150	0.04113	358.15	391.05	1.2584	0.03633	357.61	390.31	1.2475
160	0.04227	368.32	402.14	1.2843	0.03736	367.82	401.44	1.2735
170	0.04340	378.61	413.33	1.3098	0.03838	378.14	412.68	1.2992
180	0.04452	389.02	424.63	1.3351	0.03939	388.57	424.02	1.3245
	P = 1.00 MPa (T_{sat} = 39.39°C)				P = 1.20 MPa (T_{sat} = 46.32°C)			
Sat.	0.02020	247.77	267.97	0.9043	0.01663	251.03	270.99	0.9023
40	0.02029	248.39	268.68	0.9066	–	–	–	–
50	0.02171	258.48	280.19	0.9428	0.01712	254.98	275.52	0.9164
60	0.02301	268.35	291.36	0.9768	0.01835	265.42	287.44	0.9527
70	0.02423	278.11	302.34	1.0093	0.01947	275.69	298.96	0.9868
80	0.02538	287.82	313.20	1.0405	0.02051	285.62	310.24	1.0192
90	0.02649	297.53	324.01	1.0707	0.02150	295.59	321.39	1.0503
100	0.02755	307.27	334.82	1.1000	0.02244	305.54	332.47	1.0804
110	0.02858	317.06	345.65	1.1286	0.02335	315.50	343.52	1.1096
120	0.02959	326.93	356.62	1.1567	0.02423	325.51	354.58	1.1381
130	0.03058	336.88	367.46	1.1841	0.02508	335.58	365.68	1.1660
140	0.03154	346.92	378.46	1.2111	0.02592	345.73	376.83	1.1933
150	0.03250	357.06	389.56	1.2376	0.02674	355.95	388.04	1.2201
160	0.03344	367.31	400.74	1.2638	0.02754	366.27	399.33	1.2465
170	0.03436	377.66	412.02	1.2895	0.02834	376.69	410.70	1.2724
180	0.03528	388.12	423.40	1.3149	0.02912	387.21	422.16	1.2980
	P = 1.40 MPa (T_{sat} = 52.43°C)				P = 1.60 MPa (T_{sat} = 57.92°C)			
Sat.	0.01405	253.74	273.40	0.9003	0.01208	256.00	275.33	0.8982
60	0.01495	262.17	283.10	0.9297	0.01233	258.48	278.20	0.9069
70	0.01603	272.87	295.31	0.9658	0.01340	269.89	291.33	0.9457
80	0.01701	283.29	307.10	0.9997	0.01435	280.78	303.74	0.9813
90	0.01792	293.55	318.63	1.0319	0.01521	291.39	315.72	1.0148
100	0.01878	303.73	330.02	1.0628	0.01601	301.84	327.46	1.0467
110	0.01960	313.88	341.32	1.0927	0.01677	312.20	339.04	1.0773
120	0.02039	324.05	352.59	1.1218	0.01750	322.53	350.53	1.1069
130	0.02115	334.25	363.86	1.1501	0.01820	332.87	361.99	1.1357
140	0.02189	344.50	375.15	1.1777	0.01887	343.24	373.44	1.1638
150	0.02262	354.82	386.49	1.2048	0.01953	353.66	384.91	1.1912
160	0.02333	365.22	397.89	1.2315	0.02017	364.15	395.43	1.2181
170	0.02403	375.71	409.36	1.2576	0.02080	374.71	407.99	1.2445
180	0.02472	386.29	420.90	1.2834	0.02142	385.35	419.62	1.2704
190	0.02541	396.96	432.53	1.3088	0.02203	396.08	431.33	1.2960
200	0.02608	407.73	444.24	1.3338	0.02263	406.90	443.11	1.3212

Table C.8b Superheated Refrigerant-134a Vapor (Metric Units) *continued*

T °C	v m³/kg	u kJ/kg	h kJ/kg	s kJ/(kg·K)	v m³/kg	u kJ/kg	h kJ/kg	s kJ/(kg·K)
40	0.08660	260.17	284.42	1.0494	0.07518	259.61	283.67	1.0367
50	0.08992	268.64	293.81	1.0789	0.07815	268.14	293.15	1.0665
60	0.09319	277.23	303.32	1.1079	0.08106	276.79	302.72	1.0957
70	0.09641	285.96	312.95	1.1364	0.08392	285.56	312.41	1.1243
80	0.09960	294.82	322.71	1.1644	0.08674	294.46	322.22	1.1525
90	0.10275	303.83	332.60	1.1920	0.08953	303.50	332.15	1.1802
100	0.10587	312.98	342.62	1.2193	0.09229	312.68	342.21	1.2076
110	0.10897	322.27	352.78	1.2461	0.09503	322.00	352.40	1.2345
120	0.11205	331.71	363.08	1.2727	0.09774	331.45	362.73	1.2611
	P = 0.40 MPa (T_{sat} = 8.93°C)				P = 0.50 MPa (T_{sat} = 15.74°C)			
Sat.	0.05089	231.97	252.32	0.9145	0.04086	235.64	256.07	0.9117
10	0.05119	232.87	253.35	0.9182	–	–	–	–
20	0.05397	241.37	262.96	0.9515	0.04188	239.40	260.34	0.9264
30	0.05662	249.89	272.54	0.9837	0.04416	248.20	270.28	0.9597
40	0.05917	258.47	282.14	1.0148	0.04633	256.99	280.16	0.9918
50	0.06164	267.13	291.79	1.0452	0.04842	265.83	290.04	1.0229
60	0.06405	275.89	301.51	1.0748	0.05043	274.73	299.95	1.0531
70	0.06641	284.75	311.32	1.1038	0.05240	283.72	309.92	1.0825
80	0.06873	293.73	321.23	1.1322	0.05432	292.80	319.96	1.1114
90	0.07102	302.84	331.25	1.1602	0.05620	302.00	330.10	1.1397
100	0.07327	312.07	341.38	1.1878	0.05805	311.31	340.33	1.1675
110	0.07550	321.44	351.64	1.2149	0.05988	320.74	350.68	1.1949
120	0.07771	330.94	362.03	1.2417	0.06168	330.30	361.14	1.2218
130	0.07991	340.58	372.54	1.2681	0.06347	339.98	371.72	1.2484
140	0.08208	350.35	383.18	1.2941	0.06524	349.79	382.42	1.2746
	P = 0.60 MPa (T_{sat} = 21.58°C)				P = 0.70 MPa (T_{sat} = 26.72°C)			
Sat.	0.03408	238.74	259.19	0.9097	0.02918	241.42	261.85	0.9080
30	0.03581	246.41	267.89	0.9388	0.02979	244.51	265.37	0.9197
40	0.03774	255.45	278.09	0.9719	0.03157	253.83	275.93	0.9539
50	0.03958	264.48	288.23	1.0037	0.03324	263.08	286.35	0.9867
60	0.04134	273.54	298.35	1.0346	0.03482	272.31	296.69	1.0182
70	0.04304	282.66	308.48	1.0645	0.03634	281.57	307.01	1.0487
80	0.04469	291.86	318.67	1.0938	0.03781	290.88	317.35	1.0784
90	0.04631	301.14	328.93	1.1225	0.03924	300.27	327.74	1.1074
100	0.04790	310.53	339.27	1.1505	0.04064	309.74	338.19	1.1358
110	0.04946	320.03	349.70	1.1781	0.04201	319.31	348.71	1.1637
120	0.05099	329.64	360.24	1.2053	0.04335	328.98	359.33	1.1910
130	0.05251	339.38	370.88	1.2320	0.04468	338.76	370.04	1.2179
140	0.05402	349.23	381.64	1.2584	0.04599	348.66	380.86	1.2444
150	0.05550	359.21	392.52	1.2844	0.04729	358.68	391.79	1.2706
160	0.05698	369.32	403.51	1.3100	0.04857	368.82	402.82	1.2963
	P = 0.80 MPa (T_{sat} = 31.33°C)				P = 0.90 MPa (T_{sat} = 35.53°C)			
Sat.	0.02547	243.78	264.15	0.9066	0.02255	245.88	266.18	0.9054
40	0.02691	252.13	273.66	0.9374	0.02325	250.32	271.25	0.9217
50	0.02846	261.62	284.39	0.9711	0.02472	260.09	282.34	0.9566
60	0.02992	271.04	294.98	1.0034	0.02609	269.72	293.21	0.9897
70	0.03131	280.45	305.50	1.0345	0.02738	279.30	303.94	1.0214
80	0.03264	289.89	316.00	1.0647	0.02861	288.87	314.62	1.0521

L-2/T-1/ME

Date : 19/11/2012

BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY, DHAKA

L-2/T-1 B. Sc. Engineering Examinations 2011-2012

Sub : **ME 241** (Engineering Mechanics)

Full Marks: 280 Time : 3 Hours

USE SEPARATE SCRIPTS FOR EACH SECTION

The figures in the margin indicate full marks.

SECTION – A

There are **FOUR** questions in this Section. Answer any **THREE**.

Symbols indicate their usual meaning. Assume any missing data.

1. (a) The slider block A, as shown in Fig. 1(a), starts from rest and moves to the left with a constant acceleration. Knowing that the velocity of block B is 304.8 mm/s after moving 609.6 mm, determine (i) the acceleration of A and B, (ii) the velocity and position of A after 5 s. **(23)**

   (b) Two wires AC and BC are tied together at C to a sphere which revolves at a constant speed v in the horizontal circle as shown in Fig. 1(b). Determine the range of values of v for which both wires remain taut. **(23⅓)**

2. (a) The 3-kg collar is initially at rest and is acted upon by the force Q which varies as shown in Fig. 2(a). Knowing that $\mu_k = 0.25$, determine the velocity of the collar at (i) $t = 1$ s, (ii) $t = 2$ s. Solve the problem using the principle of impulse and momentum. **(23)**

   (b) A 1.4-kg collar is attached to a spring and slides without friction along a circular rod which lies in a vertical plane as shown in Fig. 2(b). The spring has a constant $k = 25$ N/mm and is undeformed when the collar is at B. Knowing the collar passes through point D with a speed of 1 m/s, determine the speed of the collar as it passes through (i) point C, (ii) point B. **(23⅓)**

3. (a) A rectangular plate is supported by two 150-mm links as shown in Fig. 3(a). Knowing that at the instant shown the angular velocity of link AB is 4 rad/s clockwise, determine (i) the angular velocity of the plate, (ii) the velocity of the center of the plate. **(23)**

   (b) End A of rod AB, as shown in Fig. 3(b), moves to the right with a constant velocity of 2 m/s. For the position shown, determine (i) the angular acceleration of rod AB, (ii) the acceleration of the midpoint G of rod AB. **(23⅓)**

4. (a) The double pulley shown in Fig. 4(a) has a total mass of 6 kg and a centroidal radius of gyration of 135 mm. Five collars (weights), each of mass 1.2 kg, are attached to cords A and B as shown in the figure. When the system is at rest and in equilibrium, one collar is removed from cord B. Neglecting friction, determine (i) the angular acceleration of the pulley, (ii) the velocity of cord A at $t = 2$ s. **(23)**

Contd P/2

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Contd Q. No. 4

(b) The 9-kg rod AB is attached by pins to two 6-kg uniform disks as shown in Fig. 4(b). The assembly rolls without sliding on a horizontal surface. If the assembly is released from rest when $\theta = 60^\circ$, determine the angular velocity of the disks when $\theta = 90^\circ$. **(23⅓)**

SECTION – B

There are **FOUR** questions in this Section. Answer any **THREE**.

5. (a) A 450-kg crate is to be supported by the rope-and pulley arrangement as shown in Fig. 5(a). Determine the magnitude and direction of the force F which should be exerted on the free end of the rope. **(20)**

   (b) Determine the polar moment of inertia of the shaded area as shown in Fig. 5(b) with respect to the centroid of the area. **(26⅔)**

6. (a) The frame ACD is hinged at A and D and supported by a cable which passes through a ring at B and is attached to hooks at G and H as shown in Fig. 6(a). Knowing that the tension in the cable is 1125 N, determine the moment about the diagonal AD of the force exerted on the frame by portion BH of the cable. **(23)**

   (b) One end of rod AB rests in the corner A and the other is attached to cord BD as shown in Fig. 6(b). If the rod supports 200-N load at its midpoint C, find the reaction at A and the tension in the cord. **(23⅔)**

7. (a) Determine the distance h for which the centroid of the shaded area as shown in Fig. 7(a) is as high above line BB' as possible when $k = 0.10$. **(23)**

   (b) Determine the force in members FH and GH of the truss as shown in Fig. 7(b) when $P = 35$ kN. **(23⅔)**

8. (a) The frame as shown in Fig. 8(a) is loaded by a clockwise couple of magnitude 150 N-m applied at point A. Determine the components of the reactions at D and E. **(23)**

   (b) A cord is attached to and partially wound around a cylinder of weight W and radius r which rests on an incline as shown in Fig. 8(b). Knowing that $\theta = 30^\circ$, find (i) the tension in the cord, (ii) the smallest value of the coefficient of static friction between the cylinder and the incline for which equilibrium is maintained. **(23⅔)**

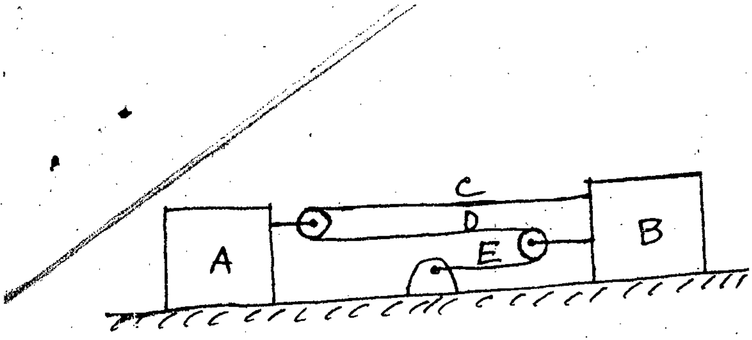

Fig. 1(a)

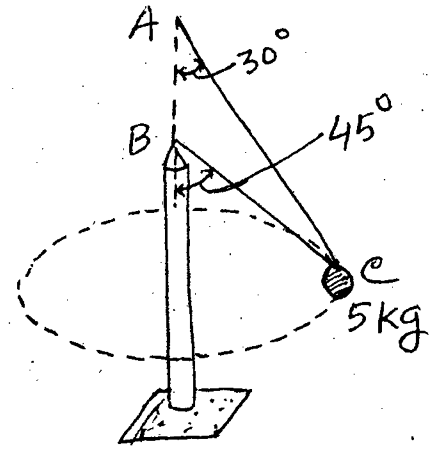

Fig. 1(b)

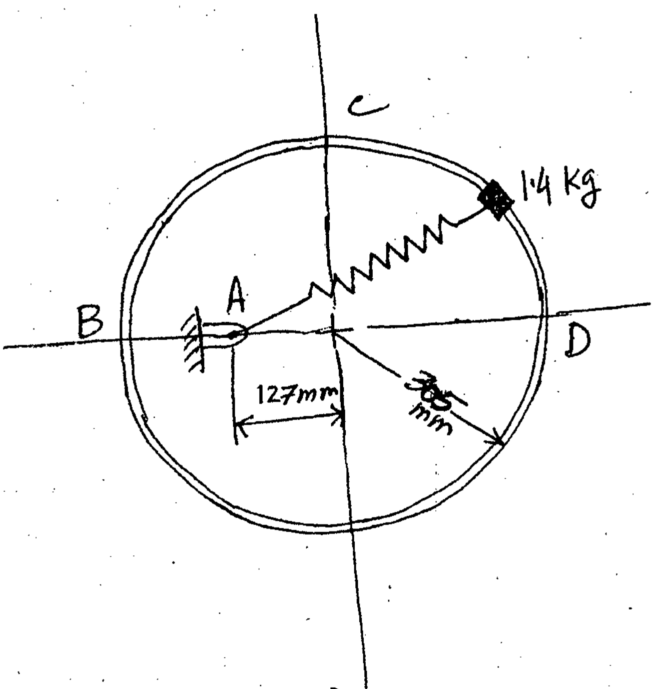

Fig. 2(b)

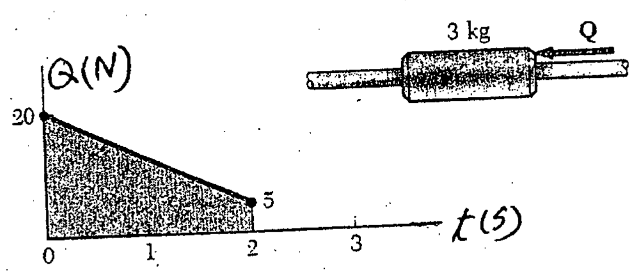

Fig. 2(a)

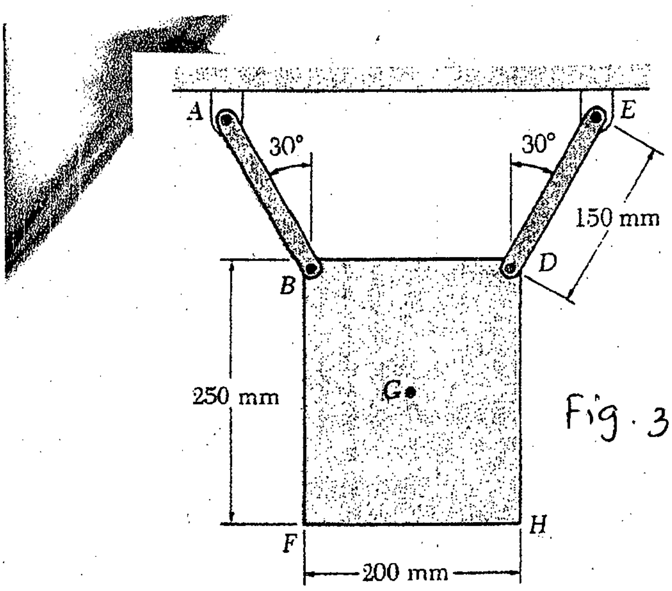

Fig. 3(a)

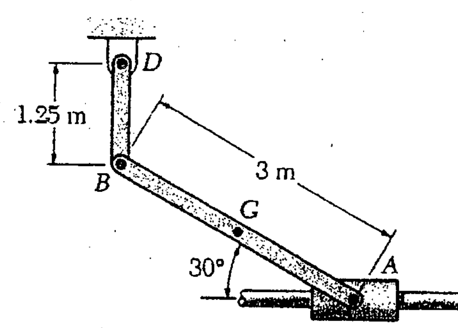

Fig. 3(b)

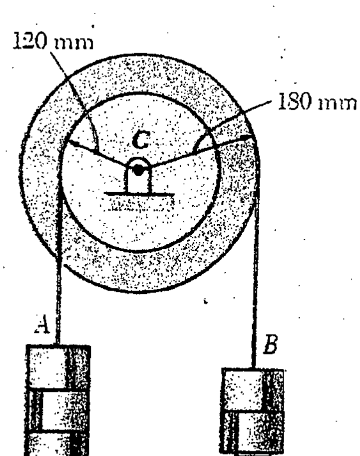

Fig. 4(a)

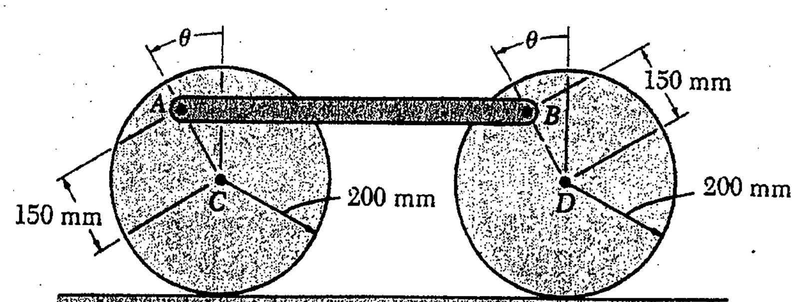

Fig. 4(b)

(4)

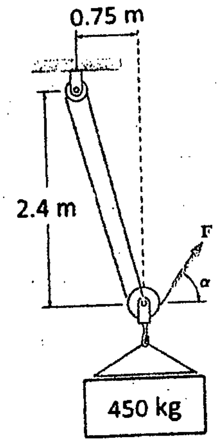

Fig. 5(a)

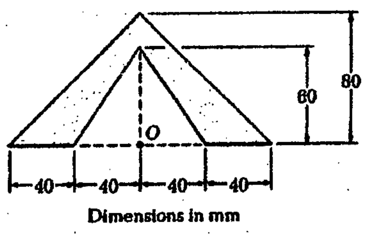

Fig. 5(b)

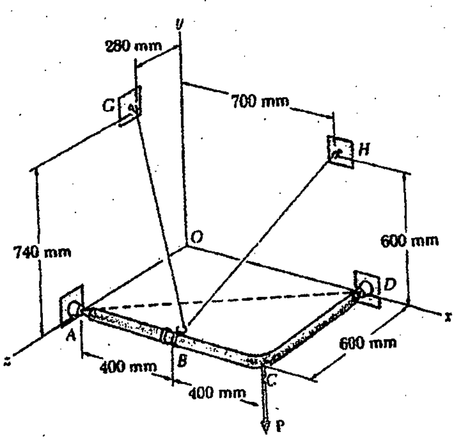

Fig. 6(a)

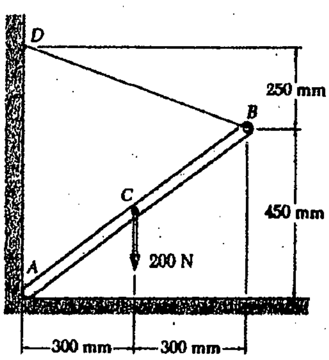

Fig. 6(b)

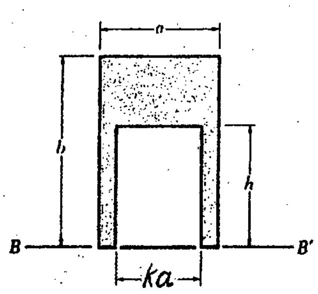

Fig. 7(a)

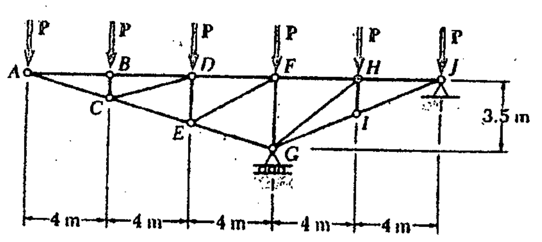

Fig. 7(b)

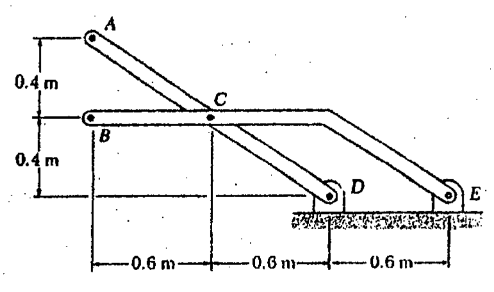

Fig. 8(a)

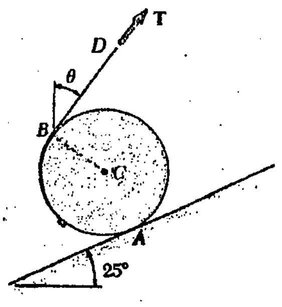

Fig. 8(b)