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Mechanical Engineering

TIME : **3** HOURS

MAXIMUM MARKS : **300**

INSTRUCTIONS :

1. ***All*** *questions are* ***compulsory****.*
2. *Question Paper may be divided into* ***4 (four)*** *Sections from* ***Section-A*** *to* ***Section-D*** *and carry marks as under :*
   - **a.** ***Section - A*** *- Total* ***3*** *Questions having* ***two*** *parts, i.e.* ***(a) and (b)*** *each questions carries* ***12*** *marks × 3 Questions = Total* ***36*** *Marks.*
   - **b.** ***Section - B*** *- Total* ***3*** *Questions having* ***two*** *parts, i.e.* ***(a) and (b)*** *each questions carries* ***20*** *marks × 3 Questions = Total* ***60*** *Marks.*
   - **c.** ***Section - C*** *- Total* ***3*** *Questions having* ***two*** *parts, i.e.* ***(a) and (b)*** *each questions carries* ***28*** *marks × 3 Questions = Total* ***84*** *Marks.*
   - **d.** ***Section - D*** *- Total* ***3*** *Questions having* ***two*** *parts, i.e.* ***(a) and (b)*** *each questions carries* ***40*** *marks × 3 Questions = Total* ***120*** *Marks.*

SECTION - A

Each questions carries ***12*** *marks.*

1 (a) A four-stroke four cylinder SI engine develops 40 kW of brake power. The volumetric air flow rate inside each cylinder is found to be 0.5 m^3/min when measured at 27°C and atmospheric pressure under test conditions. The heating value of fuel is 40 MJ/kg and the theoretical air-fuel ratio is 10. If the mechanical efficiency of the engine is 80%, determine its indicated thermal efficiency. **8**

(b) Mention how compression ratio and spark timing affect the knocking in SI engines. **4**

TABLE A-3 Properties of Saturated Water (Liquid–Vapor): Pressure Table

H_2O

		Specific Volume m^3/kg		Internal Energy kJ/kg		Enthalpy kJ/kg			Entropy kJ/kg · K		
Press. bar	Temp. °C	Sat. Liquid $v_f \times 10^3$	Sat. Vapor v_g	Sat. Liquid u_f	Sat. Vapor u_g	Sat. Liquid h_f	Evap. h_{fg}	Sat. Vapor h_g	Sat. Liquid s_f	Sat. Vapor s_g	Press. bar
0.04	28.96	1.0040	34.800	121.45	2415.2	121.46	2432.9	2554.4	0.4226	8.4746	0.04
0.06	36.16	1.0064	23.739	151.53	2425.0	151.53	2415.9	2567.4	0.5210	8.3304	0.06
0.08	41.51	1.0084	18.103	173.87	2432.2	173.88	2403.1	2577.0	0.5926	8.2287	0.08
0.10	45.81	1.0102	14.674	191.82	2437.9	191.83	2392.8	2584.7	0.6493	8.1502	0.10
0.20	60.06	1.0172	7.649	251.38	2456.7	251.40	2358.3	2609.7	0.8320	7.9085	0.20
0.30	69.10	1.0223	5.229	289.20	2468.4	289.23	2336.1	2625.3	0.9439	7.7686	0.30
0.40	75.87	1.0265	3.993	317.53	2477.0	317.58	2319.2	2636.8	1.0259	7.6700	0.40
0.50	81.33	1.0300	3.240	340.44	2483.9	340.49	2305.4	2645.9	1.0910	7.5939	0.50
0.60	85.94	1.0331	2.732	359.79	2489.6	359.86	2293.6	2653.5	1.1453	7.5320	0.60
0.70	89.95	1.0360	2.365	376.63	2494.5	376.70	2283.3	2660.0	1.1919	7.4797	0.70
0.80	93.50	1.0380	2.087	391.58	2498.8	391.66	2274.1	2665.8	1.2329	7.4346	0.80
0.90	96.71	1.0410	1.869	405.06	2502.6	405.15	2265.7	2670.9	1.2695	7.3949	0.90
1.00	99.63	1.0432	1.694	417.36	2506.1	417.46	2258.0	2675.5	1.3026	7.3594	1.00
1.50	111.4	1.0528	1.159	466.94	2519.7	467.11	2226.5	2693.6	1.4336	7.2233	1.50
2.00	120.2	1.0605	0.8857	504.49	2529.5	504.70	2201.9	2706.7	1.5301	7.1271	2.00
2.50	127.4	1.0672	0.7187	535.10	2537.2	535.37	2181.5	2716.9	1.6072	7.0527	2.50
3.00	133.6	1.0732	0.6058	561.15	2543.6	561.47	2163.8	2725.3	1.6718	6.9919	3.00
3.50	138.9	1.0786	0.5243	583.95	2546.9	584.33	2148.1	2732.4	1.7275	6.9405	3.50
4.00	143.6	1.0836	0.4625	604.31	2553.6	604.74	2133.8	2738.6	1.7766	6.8959	4.00
4.50	147.9	1.0882	0.4140	622.25	2557.6	623.25	2120.7	2743.9	1.8207	6.8565	4.50
5.00	151.9	1.0926	0.3749	639.68	2561.2	640.23	2108.5	2748.7	1.8607	6.8212	5.00
6.00	158.9	1.1006	0.3157	669.90	2567.4	670.56	2086.3	2756.8	1.9312	6.7600	6.00
7.00	165.0	1.1080	0.2729	696.44	2572.5	697.22	2066.3	2763.5	1.9922	6.7080	7.00
8.00	170.4	1.1148	0.2404	720.22	2576.8	721.11	2048.0	2769.1	2.0462	6.6628	8.00
9.00	175.4	1.1212	0.2150	741.83	2580.5	742.83	2031.1	2773.9	2.0946	6.6226	9.00
10.0	179.9	1.1273	0.1944	761.68	2583.6	762.81	2015.3	2778.1	2.1387	6.5863	10.0
15.0	198.3	1.1539	0.1318	843.16	2594.5	844.84	1947.3	2792.2	2.3150	6.4448	15.0
20.0	212.4	1.1767	0.09963	906.44	2600.3	908.79	1890.7	2799.5	2.4474	6.3409	20.0
25.0	224.0	1.1973	0.07998	959.11	2603.1	962.11	1841.0	2803.1	2.5547	6.2575	25.0
30.0	233.9	1.2165	0.06668	1004.8	2604.1	1008.4	1795.7	2804.2	2.6457	6.1869	30.0
35.0	242.6	1.2347	0.05707	1045.4	2603.7	1049.8	1753.7	2803.4	2.7253	6.1253	35.0
40.0	250.4	1.2522	0.04978	1082.3	2602.3	1087.3	1714.1	2801.4	2.7964	6.0701	40.0
45.0	257.5	1.2692	0.04406	1116.2	2600.1	1121.9	1676.4	2798.3	2.8610	6.0199	45.0
50.0	264.0	1.2859	0.03944	1147.8	2597.1	1154.2	1640.1	2794.3	2.9202	5.9734	50.0
60.0	275.6	1.3187	0.03244	1205.4	2589.7	1213.4	1571.0	2784.3	3.0267	5.8892	60.0
70.0	285.9	1.3513	0.02737	1257.6	2580.5	1267.0	1505.1	2772.1	3.1211	5.8133	70.0
80.0	295.1	1.3842	0.02352	1305.6	2569.8	1316.6	1441.3	2758.0	3.2068	5.7432	80.0
90.0	303.4	1.4178	0.02048	1350.5	2557.8	1363.3	1378.9	2742.1	3.2858	5.6772	90.0
100.	311.1	1.4524	0.01803	1393.0	2544.4	1407.6	1317.1	2724.7	3.3596	5.6141	100.
110.	318.2	1.4886	0.01599	1433.7	2529.8	1450.1	1255.5	2705.6	3.4295	5.5527	110.

TABLE A-2 Properties of Saturated Water (Liquid–Vapor): Temperature Table

H_2O

		Specific Volume m^3/kg		Internal Energy kJ/kg		Enthalpy kJ/kg			Entropy kJ/kg · K		
Temp. °C	Press. bar	Sat. Liquid $v_f \times 10^3$	Sat. Vapor v_g	Sat. Liquid u_f	Sat. Vapor u_g	Sat. Liquid h_f	Evap. h_{fg}	Sat. Vapor h_g	Sat. Liquid s_f	Sat. Vapor s_g	Temp. °C
.01	0.00611	1.0002	206.136	0.00	2375.3	0.01	2501.3	2501.4	0.0000	9.1562	.01
4	0.00813	1.0001	157.232	16.77	2380.9	16.78	2491.9	2508.7	0.0610	9.0514	4
5	0.00872	1.0001	147.120	20.97	2382.3	20.98	2489.6	2510.6	0.0761	9.0257	5
6	0.00935	1.0001	137.734	25.19	2383.6	25.20	2487.2	2512.4	0.0912	9.0003	6
8	0.01072	1.0002	120.917	33.59	2386.4	33.60	2482.5	2516.1	0.1212	8.9501	8
10	0.01228	1.0004	106.379	42.00	2389.2	42.01	2477.7	2519.8	0.1510	8.9008	10
11	0.01312	1.0004	99.857	46.20	2390.5	46.20	2475.4	2521.6	0.1658	8.8765	11
12	0.01402	1.0005	93.784	50.41	2391.9	50.41	2473.0	2523.4	0.1806	8.8524	12
13	0.01497	1.0007	88.124	54.60	2393.3	54.60	2470.7	2525.3	0.1953	8.8285	13
14	0.01598	1.0008	82.848	58.79	2394.7	58.80	2468.3	2527.1	0.2099	8.8048	14
15	0.01705	1.0009	77.926	62.99	2396.1	62.99	2465.9	2528.9	0.2245	8.7814	15
16	0.01818	1.0011	73.333	67.18	2397.4	67.19	2463.6	2530.8	0.2390	8.7582	16
17	0.01938	1.0012	69.044	71.38	2398.8	71.38	2461.2	2532.6	0.2535	8.7351	17
18	0.02064	1.0014	65.038	75.57	2400.2	75.58	2458.8	2534.4	0.2679	8.7123	18
19	0.02198	1.0016	61.293	79.76	2401.6	79.77	2456.5	2536.2	0.2823	8.6897	19
20	0.02339	1.0018	57.791	83.95	2402.9	83.96	2454.1	2538.1	0.2966	8.6672	20
21	0.02487	1.0020	54.514	88.14	2404.3	88.14	2451.8	2539.9	0.3109	8.6450	21
22	0.02645	1.0022	51.447	92.32	2405.7	92.33	2449.4	2541.7	0.3251	8.6229	22
23	0.02810	1.0024	48.574	96.51	2407.0	96.52	2447.0	2543.5	0.3393	8.6011	23
24	0.02985	1.0027	45.883	100.70	2408.4	100.70	2444.7	2545.4	0.3534	8.5794	24
25	0.03169	1.0029	43.360	104.88	2409.8	104.89	2442.3	2547.2	0.3674	8.5580	25
26	0.03363	1.0032	40.994	109.06	2411.1	109.07	2439.9	2549.0	0.3814	8.5367	26
27	0.03567	1.0035	38.774	113.25	2412.5	113.25	2437.6	2550.8	0.3954	8.5156	27
28	0.03782	1.0037	36.690	117.42	2413.9	117.43	2435.2	2552.6	0.4093	8.4946	28
29	0.04008	1.0040	34.733	121.60	2415.2	121.61	2432.8	2554.5	0.4231	8.4739	29
30	0.04246	1.0043	32.894	125.78	2416.6	125.79	2430.5	2556.3	0.4369	8.4533	30
31	0.04496	1.0046	31.165	129.96	2418.0	129.97	2428.1	2558.1	0.4507	8.4329	31
32	0.04759	1.0050	29.540	134.14	2419.3	134.15	2425.7	2559.9	0.4644	8.4127	32
33	0.05034	1.0053	28.011	138.32	2420.7	138.33	2423.4	2561.7	0.4781	8.3927	33
34	0.05324	1.0056	26.571	142.50	2422.0	142.50	2421.0	2563.5	0.4917	8.3728	34
35	0.05628	1.0060	25.216	146.67	2423.4	146.68	2418.6	2565.3	0.5053	8.3531	35
36	0.05947	1.0063	23.940	150.85	2424.7	150.86	2416.2	2567.1	0.5188	8.3336	36
38	0.06632	1.0071	21.602	159.20	2427.4	159.21	2411.5	2570.7	0.5458	8.2950	38
40	0.07384	1.0078	19.523	167.56	2430.1	167.57	2406.7	2574.3	0.5725	8.2570	40
45	0.09593	1.0099	15.258	188.44	2436.8	188.45	2394.8	2583.2	0.6387	8.1648	45

TABLE A-4 (*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
	p = 40 bar = 4.0 MPa (T_{sat} = 250.4°C)				p = 60 bar = 6.0 MPa (T_{sat} = 275.64°C)			
Sat.	0.04978	2602.3	2801.4	6.0701	0.03244	2589.7	2784.3	5.8892
280	0.05546	2680.0	2901.8	6.2568	0.03317	2605.2	2804.2	5.9252
320	0.06199	2767.4	3015.4	6.4553	0.03876	2720.0	2952.6	6.1846
360	0.06788	2845.7	3117.2	6.6215	0.04331	2811.2	3071.1	6.3782
400	0.07341	2919.9	3213.6	6.7690	0.04739	2892.9	3177.2	6.5408
440	0.07872	2992.2	3307.1	6.9041	0.05122	2970.0	3277.3	6.6853
500	0.08643	3099.5	3445.3	7.0901	0.05665	3082.2	3422.2	6.8803
540	0.09145	3171.1	3536.9	7.2056	0.06015	3156.1	3517.0	6.9999
600	0.09885	3279.1	3674.4	7.3688	0.06525	3266.9	3658.4	7.1677
640	0.1037	3351.8	3766.6	7.4720	0.06859	3341.0	3752.6	7.2731
700	0.1110	3462.1	3905.9	7.6198	0.07352	3453.1	3894.1	7.4234
740	0.1157	3536.6	3999.6	7.7141	0.07677	3528.3	3989.2	7.5190
	p = 80 bar = 8.0 MPa (T_{sat} = 295.06°C)				p = 100 bar = 10.0 MPa (T_{sat} = 311.06°C)			
Sat.	0.02352	2569.8	2758.0	5.7432	0.01803	2544.4	2724.7	5.6141
320	0.02682	2662.7	2877.2	5.9489	0.01925	2588.8	2781.3	5.7103
360	0.03089	2772.7	3019.8	6.1819	0.02331	2729.1	2962.1	6.0060
400	0.03432	2863.8	3138.3	6.3634	0.02641	2832.4	3096.5	6.2120
440	0.03742	2946.7	3246.1	6.5190	0.02911	2922.1	3213.2	6.3805
480	0.04034	3025.7	3348.4	6.6586	0.03160	3005.4	3321.4	6.5282
520	0.04313	3102.7	3447.7	6.7871	0.03394	3085.6	3425.1	6.6622
560	0.04582	3178.7	3545.3	6.9072	0.03619	3164.1	3526.0	6.7864
600	0.04845	3254.4	3642.0	7.0206	0.03837	3241.7	3625.3	6.9029
640	0.05102	3330.1	3738.3	7.1283	0.04048	3318.9	3723.7	7.0131
700	0.05481	3443.9	3882.4	7.2812	0.04358	3434.7	3870.5	7.1687
740	0.05729	3520.4	3978.7	7.3782	0.04560	3512.1	3968.1	7.2670
	p = 120 bar = 12.0 MPa (T_{sat} = 324.75°C)				p = 140 bar = 14.0 MPa (T_{sat} = 336.75°C)			
Sat.	0.01426	2513.7	2684.9	5.4924	0.01149	2476.8	2637.6	5.3717
360	0.01811	2678.4	2895.7	5.8361	0.01422	2617.4	2816.5	5.6602
400	0.02108	2798.3	3051.3	6.0747	0.01722	2760.9	3001.9	5.9448
440	0.02355	2896.1	3178.7	6.2586	0.01954	2868.6	3142.2	6.1474
480	0.02576	2984.4	3293.5	6.4154	0.02157	2962.5	3264.5	6.3143
520	0.02781	3068.0	3401.8	6.5555	0.02343	3049.8	3377.8	6.4610
560	0.02977	3149.0	3506.2	6.6840	0.02517	3133.6	3486.0	6.5941
600	0.03164	3228.7	3608.3	6.8037	0.02683	3215.4	3591.1	6.7172
640	0.03345	3307.5	3709.0	6.9164	0.02843	3296.0	3694.1	6.8326
700	0.03610	3425.2	3858.4	7.0749	0.03075	3415.7	3846.2	6.9939
740	0.03781	3503.7	3957.4	7.1746	0.03225	3495.2	3946.7	7.0952

2 (a) Why is welding of aluminum difficult ? **6**

(b) Why is graphite the most preferred electrode material in Electrodischarge Machining and why is vacuum needed in Electron Beam Machining? **6**

3 (a) The loading and unloading path for the elastic behaviour of a material is shown in the stress-strain diagram (fig. 3a), where E represents elastic limit and the material is loaded upto A. **7**

Redraw the stress-strain diagram, for the partially elastic behaviour and show for this case the loading - unloading path, residual strain and elastic recovery.

What do you understand by permanent set ?

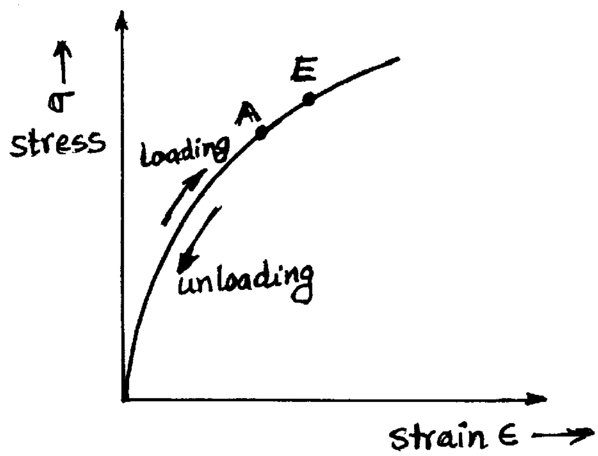

Fig. 3(a)

(b) Find the degree of freedom for the following linkage (figure 3b). **5**

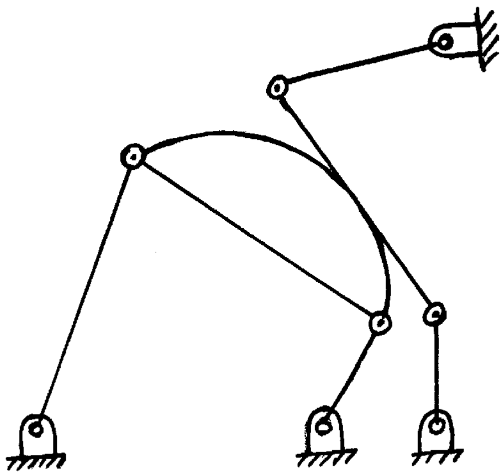

Fig. 3(b)

SECTION - B

*Each questions carries **20** marks.*

4 (a) Consider a heat engine and heat pump connected as shown in figure below. Assume $T_{H1} = T_{H2} > T_{\text{ambient}}$ and determine for each of the three cases if the setup satisfies the first law and/or violates the 2nd law. **12**

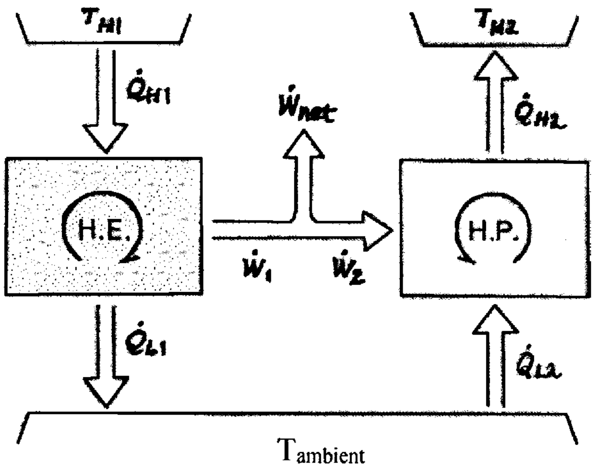

Fig. 4(a)

	$\dot{Q}_{H1}$	$\dot{Q}_{L1}$	$\dot{W}_1$	$\dot{Q}_{H2}$	$\dot{Q}_{L2}$	$\dot{W}_2$
a	6	4	2	3	2	1
b	6	4	2	5	4	1
c	3	2	1	3	3	1

(b) Show that the velocity of sound in an ideal gas is equal to $\sqrt{\gamma RT}$, where γ is the specific heat ration, R is the characteristic gas constant and T is the absolute temperature of the gas. **8**

5 (a) Taking the exponent, n = 0.3 and the value of the constant, C = 350 in Taylor's tool life equation, find the percentage increase in tool life if cutting speed is reduced by (i) 15% and (ii) 25%. **10**

(b) A cup of 50 mm diameter and 20 mm height is to be produced by drawing from a 1.5 mm thick sheet metal. Find the blank diameter and the maximum drawing force assuming that the ultimate strength of the sheet metal is 650 MN. **10**

6 (a) A machine punching 40 mm diameter holes in a 10 mm thick plate does 6 J of work per square mm of sheared area. The punch has a stroke of 100 mm and punches 5 holes per minute. The maximum speed flywheel at its radius of gyration is 30 m/s. **12**

Find the mass of the flywheel so that its speed at the radius of gyration does not fall below 25 m/s. Also determine the power of the motor driving this punching machine in kW.

(b) Draw a pinion and gear in mesh showing condition that will cause interference. Show pitch point and pressure angle. Also mark the base, pitch, addendum circles for both wheels. **8**

SECTION - C

*Each questions carries **28** marks.*

7 (a) One dimensional steady state conduction with internal energy generation is occurring in a cylindrical shell of inner radius r_1 and outer radius r_2. Under what condition is the linear temperature distribution shown in figure below possible? Assume conductivity to be constant. **12**

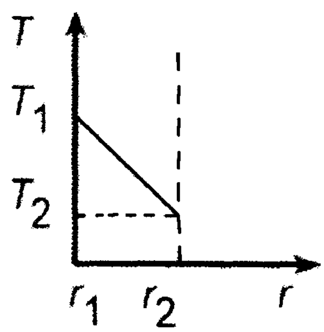

Fig. 7(a)

(b) Consider that a flat plate of Length L is at a constant temperature T_s. Air with a free stream temperature of $T_\infty \left(T_\infty < T_s\right)$ flows over the plate. The temperature distribution in air is given by **16**

$$\frac{T - T_s}{T_\infty - T_s} = \frac{3}{2}\left(\frac{y}{\delta_t}\right) - \frac{1}{2}\left(\frac{y}{\delta_t}\right)^3$$

where, thermal boundary layer thickness $\delta_t = A\sqrt{x}$

In the above equation, x and y are the coordinate axes along and perpendicular to the plate. The coordinate x is measured from the leading edge of the plate, while y is measured from the plate surface. A is a constant. Show that

$$Nu_x = \frac{3}{2}\frac{\sqrt{x}}{A}, \quad \bar{N}u_L = 2Nu_L$$

Show that the temperature profile given above satisfies at least three of the boundary conditions of thermal boundary layer.

8 (a) Punjab National Bank uses laser printer catridges at the rate of 10 per week. The prices charged by the supplier of the catridges varies with order quantity as follows : **14**

Order Quantity	**Price (in Rs)**
0-99	4000
100-249	3960
250-499	3900
500 and above	3800

PNB estimates that it pays Rs. 10,000 per order for delivery and for execution of the purchase order. In addition the PNB believes that it costs 20% per year of a catridge's price to hold it in inventory. Find out the optimal number of catridges that PNB should order at a time.

(b) Standard Metals is a small scale manufacturing organization making simple, customized metal products. The Company has six orders that has to be finished within the day and shipped. Each product is made by a two stage process. In the first stage, items are cut to the appropriate shape and size; in the second stage, they are ground and polished. Each stage is staffed with one person. The Company realizes that it will take more than 8 hours to complete the six jobs. The firm agrees to pay the overtime to the workers but wish to minimize the overtime expense. The estimated setup and processing time (in hours) for each job at each stage are as follows : **14**

Job	Stage I	Stage II
A	1.5	0.6
B	3.2	1.9
C	0.8	1.3
D	2.7	2.0
E	1.1	1.4
F	1.6	0.7

Find out the sequence in which the jobs should be done so that the overtime cost is minimum.

9 (a) An auditorium door is to be designed such that the return swing occurs in shortest possible time without oscillating. This can be achieved with a viscous damper and a torsional spring arrangement. If the door is 2.2 m high, 1.2 wide and 65 mm thick and weighs 85 kg, estimate the viscous damping coefficient required to achieve the design criteria. Assume torsional spring stiffness of 22 N.m/rad. For a thin rectangular plate, moment of inertia about an axis through centre and parallel to the edge is $\frac{1}{12} M b^2$ where M is mass and b is width. **12**

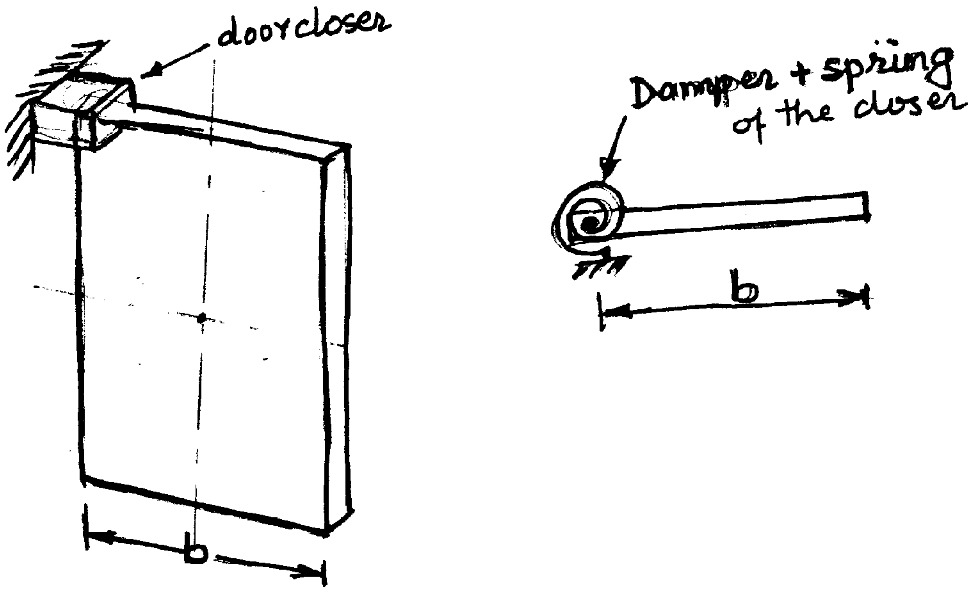

Fig. 9(a)

(b) The static deflection of an automobile on its spring suspension is 10 cm. Find the critical speed when the automobile is travelling on a road shown in the figure, which can be approximated by a sine wave of amplitude 8 cm and a wavelength 15 m. Neglect the damping of the suspension. Also determine amplitude of vibration of the automobile at 75 kmph. **16**

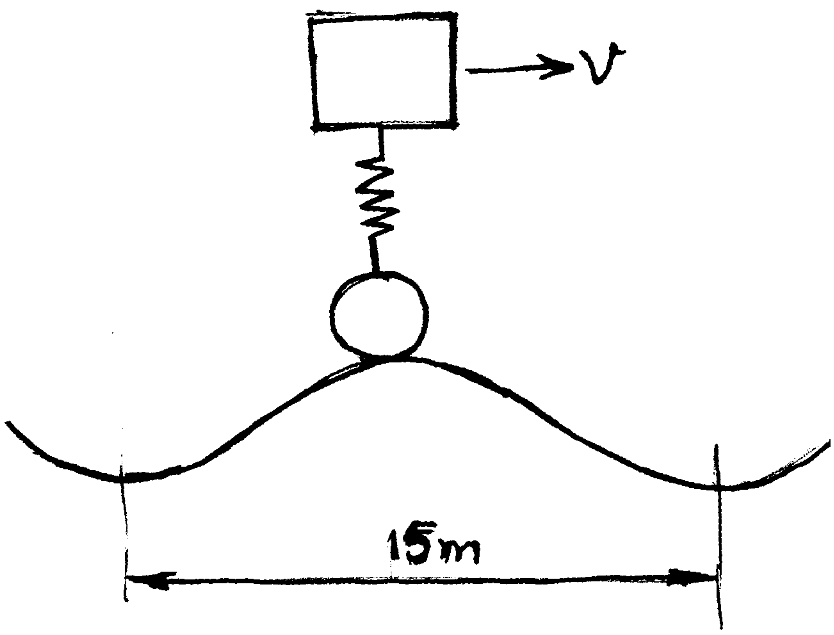

Fig. 9(b)

SECTION - D

*Each questions carries **40** marks.*

10 (a) Define dry bulb temperature, wet bulb temperature and dew point temperature. **10**

(b) Saturated air at 2°C is required to be supplied to a room where the temperature must be held at 20°C with a relative humidity of 50%. The air is heated and then water at 10°C is sprayed in to give the required humidity. Determine the temperature to which the air must be heated and the mass of spray water required per m^3 of air at room conditions. Assume that the total pressure is constant at 1.013 bar and neglect the fan power. Show the processes in Psychrometric chart. **30**

Following data can be used for saturated water :

At, 20°C: P_{sat} = 2.339 kPa

At, 2°C: P_{sat} = 0.7156 kPa

At, P_{water} = 1.17 kPa: h_g = 2518 kJ/kg and T_{sat} = 9.65 °C

Assume C_p of water at superheated state as 1.884 kJ/kg K and C_p of air to be 1.005 kJ/kg K.

11 (a) Draw the schematic of an ideal Rankine cycle with a reheat section. Plot the different processes of the cycle in a Temperature and entropy diagram. **10**

(b) Water is the working fluid in a Rankine cycle. Superheated vapor enters the turbine at 8 MPa, 480°C. The condenser pressure is 8 kPa. The net power output of the cycle is 100 MW. The turbine and pump have isentropic efficiencies of 85 and 70%, respectively. Determine for the cycle: **30**

(i) the thermal efficiency.

(ii) the rate of heat transfer to the working fluid passing through the steam generator, in kW

(iii) the mass flow rate of condenser cooling water, in kg/h, if the cooling water enters the condenser at 15°C and exits at 35°C with negligible pressure change.

12 (a) The three flat blocks are positioned on the 30° incline as shown in figure 12a. A force P is applied to the middle block in a direction parallel to the incline as shown. The upper block is prevented from moving by a wire that attached it to the fixed support as shown. The coefficient of static friction for each of the three pairs of mating surfaces is as shown. Determine the maximum value which P may have before any slipping takes places. **20**

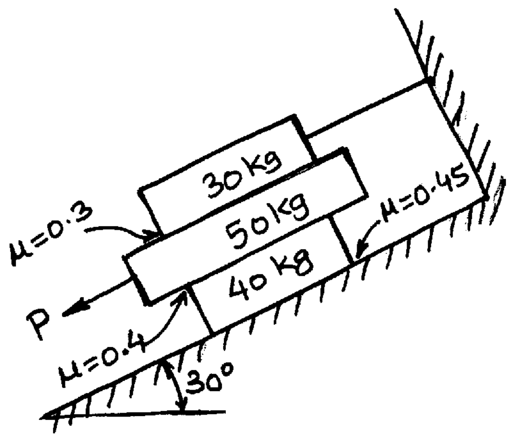

Fig. 12(a)

(b) An L-shaped rod ABC of solid circular cross section lies in a horizontal plane. Its one end is fixed to the vertical wall at A and the free end is C as shown in figure 12b. The diameter of the rod is 60 mm. A wire rope hangs freely from the free end C as shown. The rope may be assumed vertical, inextensible and massless. **20**

A person of mass 60 kg starts climbing up the rope with acceleration 2 m/s^2. Find the maximum stress at positions X and Y at the root (A) i.e. at the location where the rod connects with the wall.

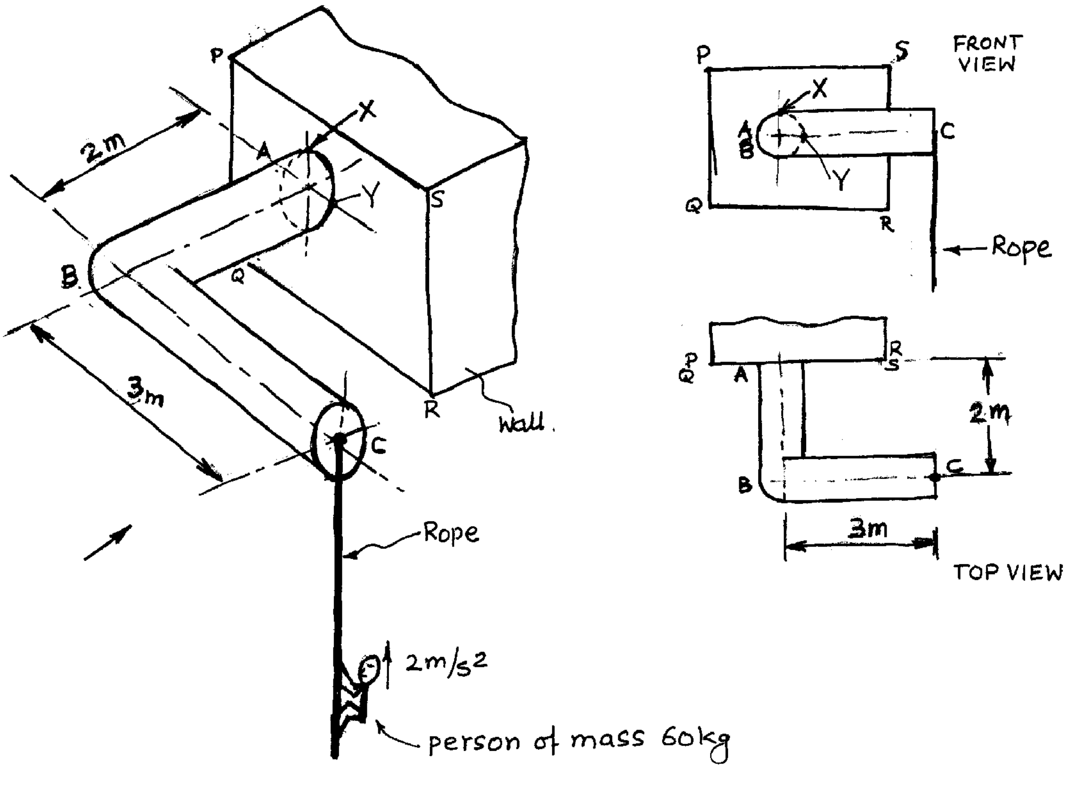

Fig. 12(b)