Reg. No.										

MANIPAL INSTITUTE OF TECHNOLOGY

MANIPAL

(A constituent unit of MAHE, Manipal)

I SEMESTER M.TECH (TSES) END SEMESTER MAKE UP EXAMINATIONS, DECEMBER 2018

SUBJECT: SOLAR THERMAL ENERGY SYSTEMS [MME 5143]

REVISED CREDIT SYSTEM

Time: 3 Hours MAX. MARKS: 50

Instructions to Candidates:

- Answer **ALL** the questions.
- Missing data may be suitably assumed.
- Use of Heat and mass transfer data book is permitted

1A. Derive an expression for collector efficiency factor in case of in-line version of solar flat plate water heater. **05**

1B. Evacuated tube collector with tank having 125 litres (at 50°C) of water is to be checked for circulation ratio and instantaneous efficiency. Available data are:

Time (h)	10.00	11.00	12.00	1.00
I_b (W/m^2)	600	650	700	750

Collector area = 3.0 m^2
Initial average temperature of water in the tank = 50°C
Final average temperature of water in the tank = 75°C
Assume diffused radiation as 15 % of beam radiation.
Neglect heat loss from storage tank. **05**

2A. With sketch explain the working of the following solar thermal systems:
(a) Adsorption and absorption refrigeration
(b) Fresnel reflector **05**

2B. Calculate H-W-B constants, Critical radiation level and collector efficiency factor for the flat plate collector with following geometry and operating conditions:

Total radiation falling on cover	=	550 W/m^2
Absorptivity-transmissivity product	=	0.85
Top loss coefficient	=	4 W/m^{2}K
Size of the collector	=	2 m(L) x 1 m(W) x 0.16 m(H)
Thermal conductivity of insulation	=	0.05 W/mK
Mass flow rate of water	=	35 kg/m^{2}h
Water inlet and outlet temperature	=	30°C and 38°C
Collector heat removal factor	=	0.85
Overall heat transfer coefficient	=	4.32 W/m^{2}K
Spacing between cover and plate	=	0.08 m
Side insulation thickness	=	50 % of back insulation **05**

3A. Derive an expression for collector efficiency factor in case of a conventional solar air heater with continuous longitudinal fins. **05**

3B. Calculate the monthly average hourly global and diffuse radiation during the month of April on a horizontal surface at New Delhi (28°35' N). Time is 0900 h to 1000 h (LAT). The average number of sunshine hours per day is 8.6. Take a = 0.25, b = 0.57.

The constants in monthly average hourly global radiation are defined as:

$a = 0.409 + 0.5016\ sin(\omega_s - 60°)$ and $b = 0.6609 - 0.4767\ sin(\omega_s - 60°)$

Monthly average daily diffused radiation is: $\frac{H_d}{H_g} = 1.411 - 1.696\left(\frac{H_g}{H_o}\right)$ **05**

4A. Discuss the effect of various parameters on performance of Parabolic trough collector. **05**

4B. A flat plate water heater operates at a mean plate temperature of 70°C. Determine the time by which it will reach this temperature if there is no useful heat gain till that time. The following data is given:

Collector length	= 1.6 m	(mC) for plates & tubes	= 4.5 kJ/K
Collector width	= 1.0 m	(mC) for insulation	= 2.0 kJ/K
Overall loss coefficient	= 7.2 W/m^{2}K	(mC) for glass cover	= 16 kJ/K
Top loss coefficient	= 6.4 W/m^{2}K	Water in collector	= 2.1 l
Ut_2	= 22.8 W/m^{2}K		

Time (am)	Flux (W/m^2)	$(\tau\alpha)_{avg}$	Ta (°C)
6-7	30	0.25	14.0
7-8	175	0.50	15.0
8-9	380	0.70	16.0
9-10	555	0.86	18.0
10-11	700	0.89	20.5

05

5A. Draw combined H-W-B graph (showing changes in intercept and slope) when conventional air heater is modified with longitudinal fins.

Length of collector	= 2.1 m
Width of collector	= 1.1 m
Length of plate	= 2.0 m
Width of plate	= 1.0 m
Space between plate and bottom plate	= 15 mm
Air flow rate	= 200 kg/h
Fin pitch	= 25 mm
Fin height	= 13 mm
Fin thickness	= 3 mm
Overall heat loss coefficient	= 7 W/m^{2}K
Equivalent radiation heat transfer coefficient	= 7.57 W/m^{2}K
Fin material	= 0.5 % C
Absorptivity-transmissivity product	= 0.85

For plain plate: $Nu = 0.158\ Re^{0.8}$

For finned plate: $Nu = 0.023\ Re^{0.8}\ Pr^{0.4}$ **05**

5B. With sketch explain I and H type layout of solar field. **05**