Universiti Tun Hussein Onn Malaysia

UNIVERSITI TUN HUSSEIN ONN MALAYSIA

FINAL EXAMINATION
SEMESTER II
SESSION 2015/2016

COURSE NAME	:	AIR CONDITIONING SYSTEM & SERVICES
COURSE CODE	:	BNB 30203
PROGRAMME CODE	:	BNB
EXAMINATION DATE	:	JUNE/ JULY 2016
DURATION	:	3 HOURS
INSTRUCTION	:	1. ANSWER **ALL** QUESTIONS IN **SECTION A** 2. ANSWER **TWO (2)** QUESTIONS IN **SECTION B**

THIS QUESTION PAPER CONSISTS OF **FOURTEEN (14)** PAGES

SECTION A

Q1 (a) Describe the function of the:

(i) Compressor
(ii) Condenser
(iii) Expansion valve
(v) Evaporator

(4 marks)

(b) **Figure Q1 (b)** shows the basic cycle of the refrigeration system.

(i) Explain the process at point (ii), (iii), (v) and (vi) and sketch the Mollier Chart to present the process.

(ii) Filter drier and Accumulator is commonly used as a accessories in the air conditioning system, sketch the location to place the part.

(8 marks)

(c) As an Engineer, you have been assigned by the company to select a suitable capacity of the air conditioner for new office room, The area size of the room are 20ft (L) x 18ft (W) x 10ft (H).

(i) Calculate the actual capacity required for the room.

(ii) Determine the actual horse power required for the room.

(8 marks)

Q2 (a) Air conditioning systems can be classified into **THREE (3)**. List all the categories as defined.

(3 marks)

(b) There are **FOUR (4)** stages in air conditioning system process as shown in **Figure Q2 (b)**. Explain the process occurred at each point:

(i) Compression - (From Point 2 to 3)
(ii) Condensation - (From Point 3 to 4)
(iii) Expansion - (From Point 4 to1)
(iv) Evaporation - (From Point 1 to 2)

(8 marks)

(c) An air conditioning unit capacity of 10 HP is able to operate as usual but does not reach comfortable temperature as required. Based from an investigation, it is found that the evaporator fan speed was running slowly even the controller was set to maximum and there was a frost build up around the suction pipe.

(i) List **TWO (2)** possible causes for this fault.

(ii) Propose solutions for these issues.

(9 marks)

Q3 (a) Describe the importance of Psychrometric chart in HVAC industries.

(2 marks)

(b) In a cold winter day, outside air of 35°F and 60% of relative humidity is heated by passing through a coil to 95°F dry bulb. Refer to **FIGURE Q3,** identify the relative humidity, wet bulb, dew point temperature and amount of added heat in the heating process at dry bulb temperature of 95°F.

(4 marks)

(c) Using **Figure Q3(c)** psychrometric chart find the proper values needed to fill in the blank spaces in the following table below:

Wet Bulb (°F)	Dry Bulb (°F)	Relative Humidity (%)	Specific volume (ft^3/lb)	Dew point (°F)	Enthalpy (btu/lb)
	45	30			
			13.8		32.5
51				40	
	35		12.52	21	

(7 marks)

(d) Given:

Air at 82°F dry bulb and 50% relative humidity being cooled to 53°F wet bulb. Find by using provided psychrometric chart:

(i) Total heat removed.
(ii) Total moisture removed.
(iii) Sensible heat ratio for the process. Given that; sensible heat ratio = sensible heat / total heat.

(7 marks)

SECTION B (ANSWER TWO (2) QUESTIONS ONLY)

Q4 (a) Determine the overall coefficient of heat transmission U for a wall consisting of 4-inches (101.6-mm) of face brick, 4-inches (101.6-mm) common brick, and 1/2-inches (12.7-mm) of gypsum plaster (sand aggregate).

(12 marks)

(b) With the help of **Figure Q4 (b)** and using the Rule Of Thumb method, determine:

(i) Determine the Heat gain for each area.

(ii) Total Heat gain in unit Horsepower and Refrigerant Tonnage.

(8 marks)

Q5 (a) Name at least **THREE (3)** types of an Alternative Current (AC) motor starter that are normally used in industry.

(3 marks)

(b) Identify the relevant electrical components and protective devices used in a standard AC motor starter.

(2 marks)

(c) **Figure Q5 (c)** given below shows a control circuit of one of the essential motor starter available in the industry.

(i) Identify the name of this motor starter.

(ii) Draw the MAIN CIRCUIT of this motor starter.

(5 marks)

(d) This question will be based on the same **Figure Q5(c)** as given above:

(i) What will happen to the functionality of the starter if the auxiliary contact **NORMALLY-CLOSED REVERSE** is not exist?

(ii) Could automatic approach be implemented by adding a self-counting **TIMER** to change the transition from forward to reverse?

(10 marks)

Q6 (a) Putra Holding Company Limited uses a centralized air conditioning system. It uses ducting system to deliver and distribute cold air. There are several numbers of offices and meeting rooms which receive the cold air exceeding the required capacity of a room.

(i) List **TWO (2)** reasons of the above situation.

(ii) Propose solution for these issues.

(5 marks)

(b) **Figure Q6 (b)** below shows the schematic of a basic air-water system.

(i) Explain how the system works and where is basically this system applied?

(ii) List **SIX (6)** disadvantages of using the air-water system.

(10 marks)

(c) Another two more unit rooms has been added and required to use Fan Coil Unit (FCU) as individual self-control system. Explain how the system work and provide figure to support your answer.

(5 marks)

- END OF QUESTION -

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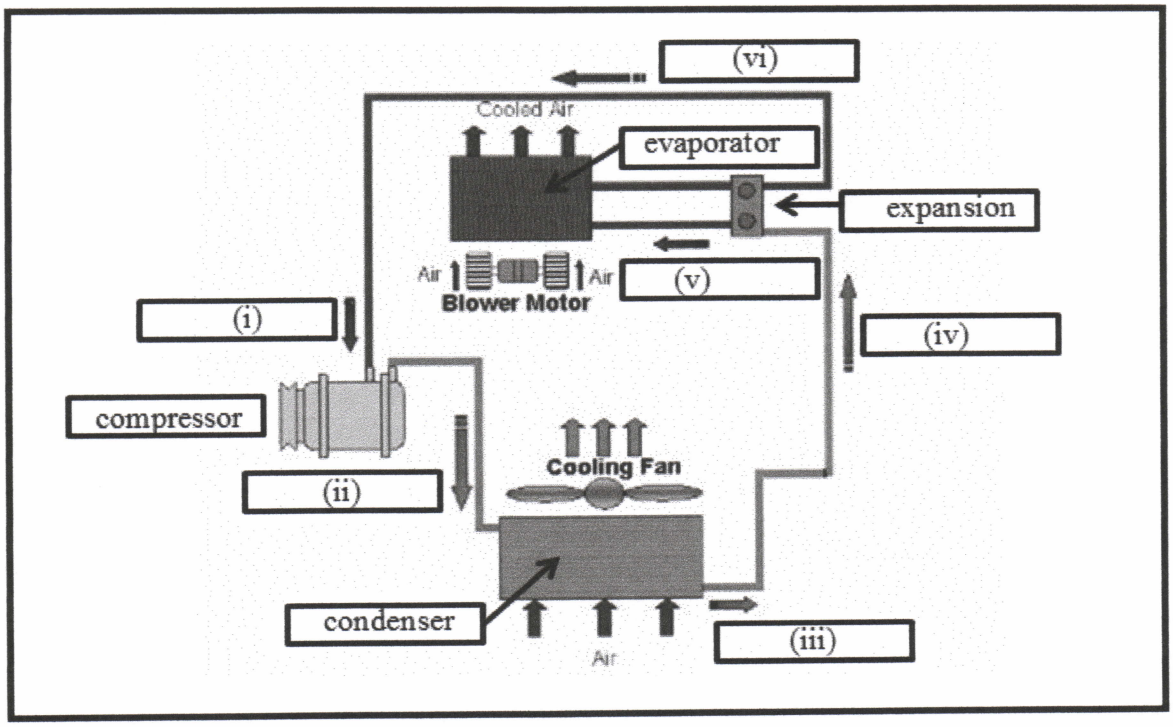

Figure Q1 (b)

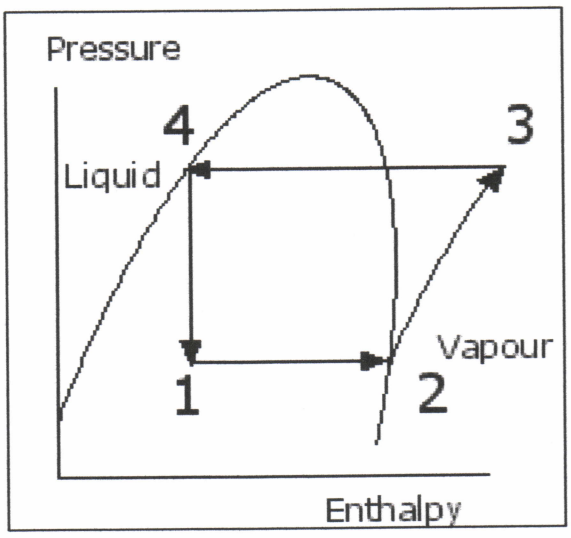

Figure Q2 (b)

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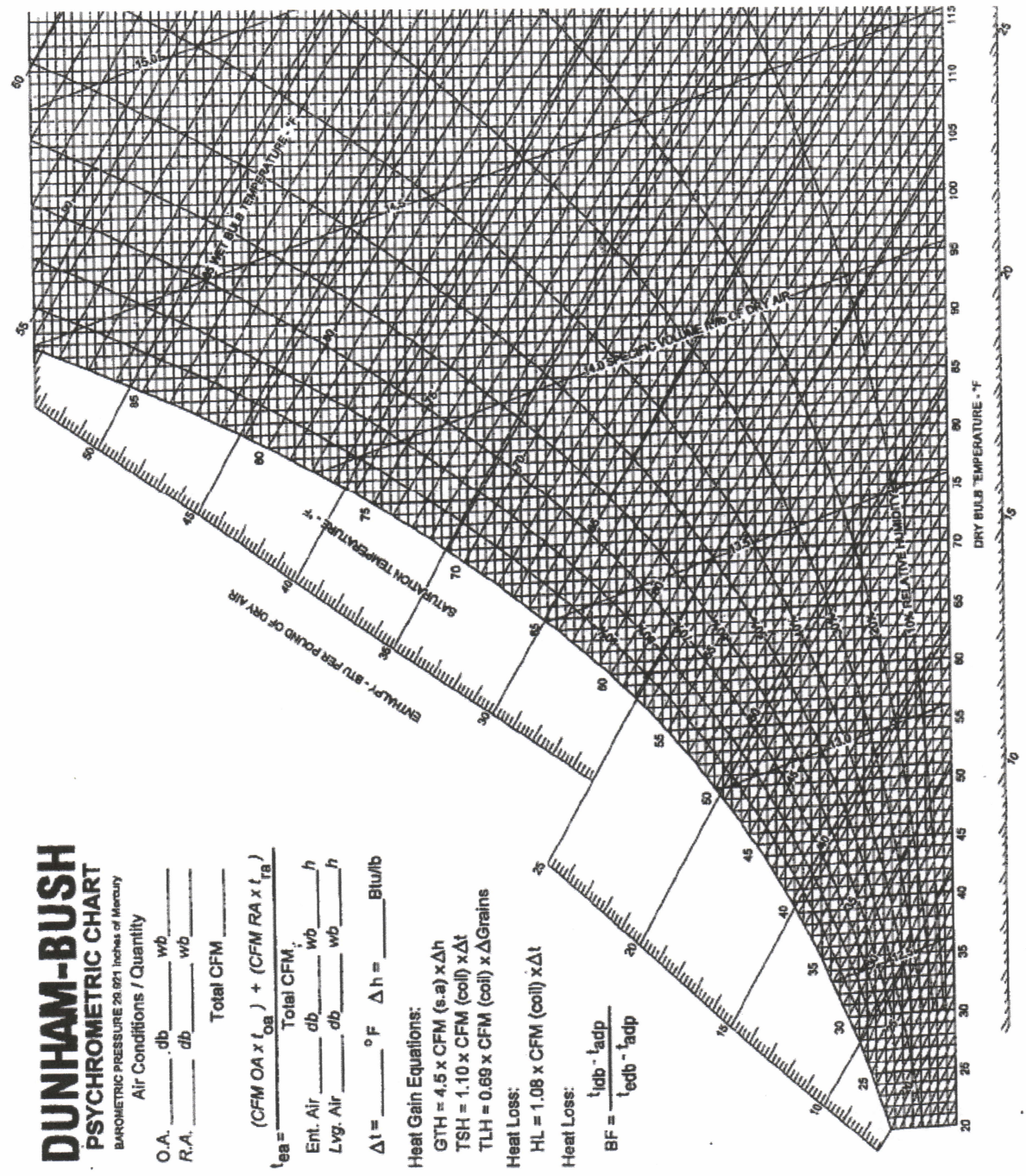

Figure Q3 (b)

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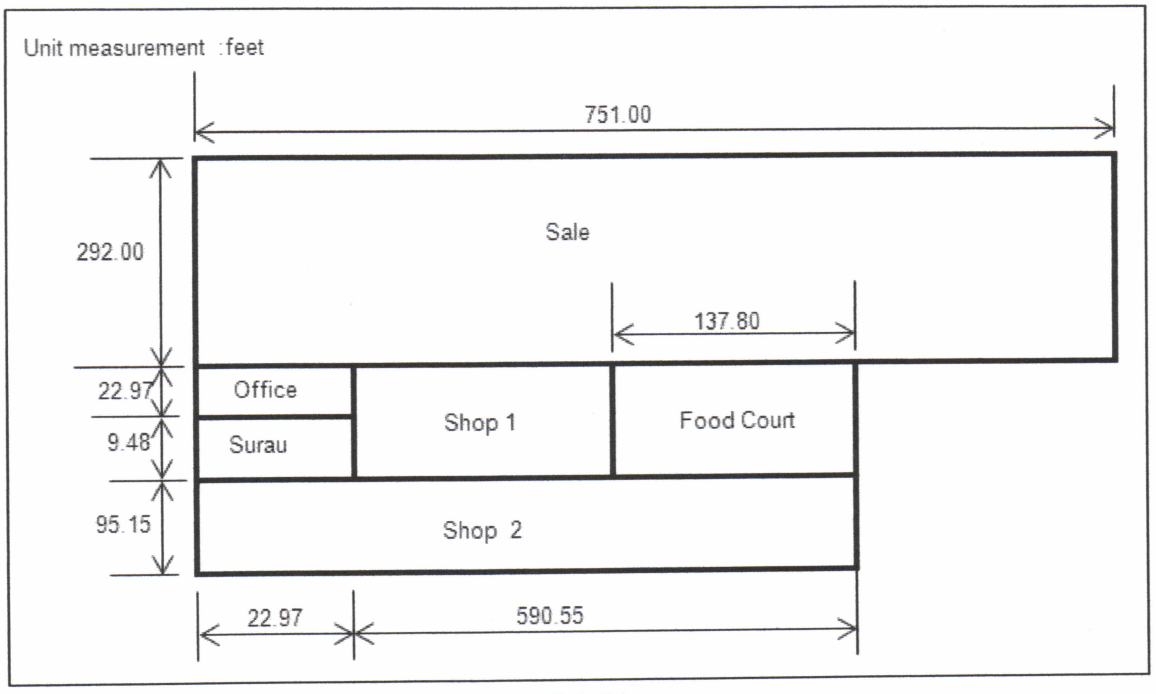

Figure Q4 (b)

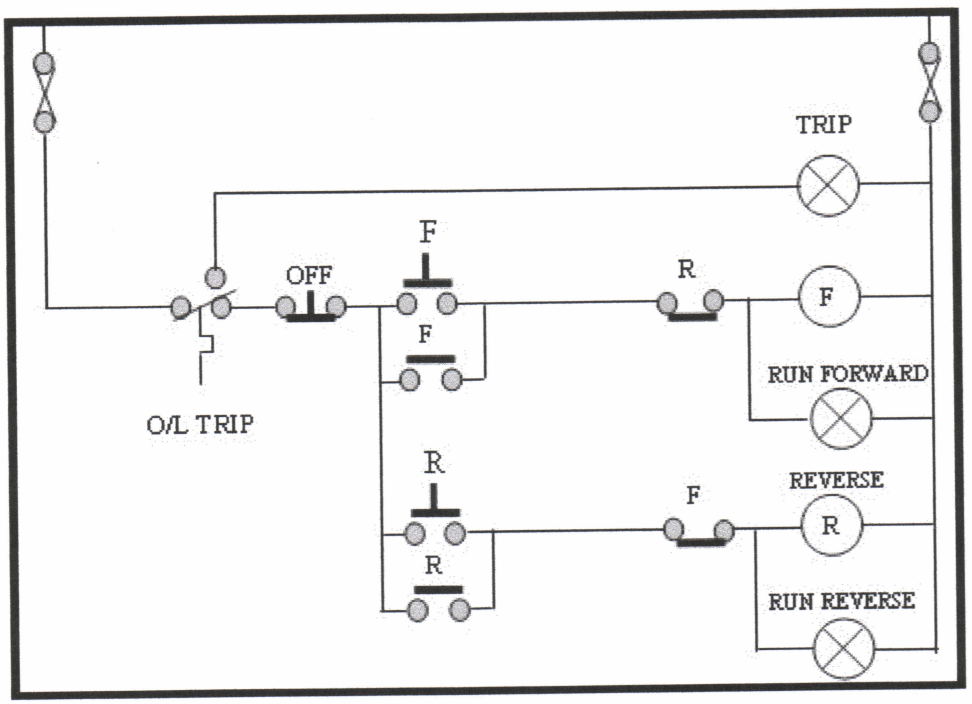

Figure Q5 (c)

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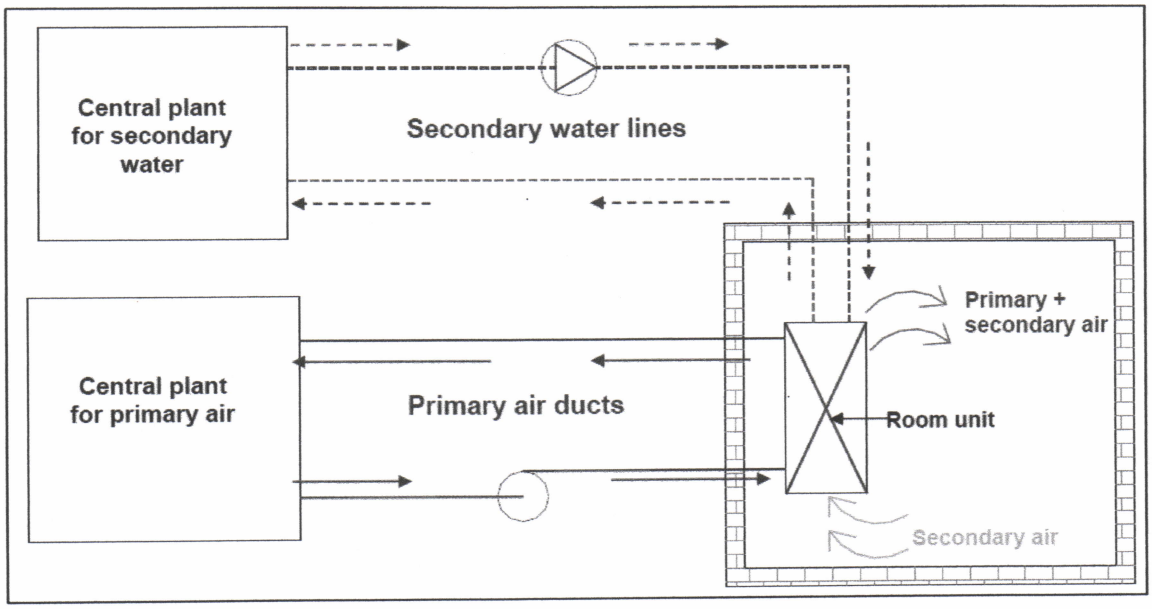

FIGURES Q6 (b)

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Table I — Design and Cooling Load Check Figures

Applications	Occupancy Sq Ft/Person			Lighting Watts/Sq Ft			Fresh CFM/Person			Air CFM/Sq Ft			Room Sensible Btuh/Sq Ft			Room Total Btuh/Sq Ft			Grand Total Btuh/Sq Ft			Refrigeration Sq Ft/Ton*			Supply Air CFM/Sq Ft		
	Lo	Avg	Hi	Lo	Avg	Hi	Lo	Avg	Hi	Lo	Avg	Hi	Lo	Avg	Hi	Lo	Avg	Hi	Lo	Avg	Hi	Lo	Avg	Hi	Lo	Avg	Hi
Apartments (Flats)	150	100	50	1.0	2.0	4.0	25	35	40	.25	.35	.50	15	25	45	20	30	50	30	40	60	400	300	200	.75	1.25	1.75
Auditoriums, Theaters	15	10	5	1.0	2.0	3.0	5.0	15	30	.50	1.5	2.5	25	35	50	45	55	70	60	80	120	200	150	100	1.25	1.5	2.5
Educational Facilities																											
Classrooms	30	25	20	2.0	4.0	6.0	5.0	7.5	10	.20	.30	.40	25	40	55	35	50	65	45	60	80	275	200	150	1.0	1.4	1.8
Laboratories	75	60	40	2.0	3.0	6.0	10	15	20	.20	.40	.60	30	40	55	35	45	65	45	60	75	275	200	160	1.0	1.4	1.8
Cafeteria – Coffee House	20	15	10	1.5	3.0	4.5	7.5	10	15	.40	.60	.80	25	45	65	35	60	75	55	80	110	225	150	110	1.0	1.5	2.1
Factories	50	35	25	3.0	4.5	6.0	5.0	10	15	.10	.25	.50	20	45	75	30	60	85	50	80	130	240	150	90	1.0	2.25	3.0
Public Areas	200	150	100	9.0‡	10.0‡	12.0‡	5.0	10	15	.05	.10	.15	35	55	75	40	60	80	60	80	120	200	150	100	1.5	2.75	3.0
Light Manufacturing	300	250	200	15.0‡	45.0‡	60.0‡	5.0	10	15	.03	.08	.10	75	115	155	80	120	160	120	150	200	100	80	60	3.0	4.0	6.5
Heavy Manufacturing**	20	15	10	1.0	1.5	2.0	5.0	10	15	.50	.75	1.0	30	35	50	40	50	70	60	85	120	200	150	100	1.0	1.1	1.4
Hospitals																											
Patient Rooms†	100	60	40	1.0	2.0	3.0	75	90	100	.75	1.6	2.5	15	35	50	20	40	55	60	120	165	200	100	75	.75	1.2	1.7
Public Areas	130	100	65	2.0	3.0	4.0	10	20	30	.25	.75	1.5	10	15	35	15	20	40	30	45	100	400	275	120	.75	1.2	1.7
Laboratories	150	100	50	2.0	5.0	10.0	20	30	50	.20	.50	1.0	25	45	60	30	55	70	45	70	100	275	175	120	1.0	1.5	2.0
Libraries	150	100	50	2.0	4.0	6.0	5.0	7.5	10	.10	.20	.30	20	30	50	25	35	55	30	45	70	400	275	175	1.0	1.1	1.7
Doctors Clinics	150	100	50	2.0	4.0	6.0	20	25	30	.25	.40	.60	20	40	60	25	45	65	40	60	80	300	200	150	1.0	1.4	2.0
Offices																											
Private	150	125	100	4.0	6.0	8.0	20	25	30	.25	.40	.60	25	50	75	30	55	80	40	75	90	300	175	135	1.0	1.7	2.4
General – Perimeter	125	100	75	4.0	6.0	8.0	10	15	20	.15	.25	.40	20	35	70	25	40	75	30	50	85	400	250	150	1.0	1.2	2.3
General – Interior	125	100	75	4.0	6.0	8.0	10	15	20	.15	.25	.40	15	20	30	20	25	35	25	30	40	475	400	300	.75	1.0	1.1
Conference Rooms	45	30	15	4.0	6.0	8.0	20	30	50	.40	1.0	1.5	30	55	80	40	65	90	60	85	120	200	150	100	1.0	1.8	2.7
Restaurants	25	20	15	1.5	1.7	2.0	10	15	20	.50	.75	1.0	30	35	50	40	50	70	60	85	120	200	150	100	1.25	1.5	2.0
Shopping Centers																											
Beauty & Barber Shops	45	40	25	3.0‡	5.0‡	9.0‡	7.5	15	20	.20	.50	1.0	25	35	55	30	40	60	50	60	80	250	200	150	1.25	1.5	2.0
Department Stores – Basement	40	30	20	3.0	4.0	5.0	5.0	7.5	10	.10	.20	.25	20	30	45	25	35	50	35	45	60	325	275	200	1.0	1.4	1.75
– Main Floor	40	25	20	4.0	6.0‡	9.0‡	5.0	7.5	10	.15	.25	.35	25	35	45	30	40	50	40	50	60	300	250	200	1.0	1.5	2.0
– Upper Floors	80	50	40	2.0	4.0	6.0‡	5.0	5.0	7.5	.05	.10	.15	15	25	35	20	30	40	30	40	50	400	300	250	.80	1.0	1.2
	40	30	25	2.0	3.0	4.0	10	15	20	.25	.35	.50	30	35	45	40	45	55	60	65	75	200	180	160	1.25	1.5	2.0
	40	25	20	3.0	4.0	6.0	5.0	7.5	10	.15	.25	.35	25	35	45	30	40	50	40	50	60	300	250	200	1.0	1.4	2.0
	60	40	30	1.0	1.5	2.0	5.0	7.5	10	.10	.20	.30	10	15	25	15	20	30	25	30	40	500	400	300	.75	1.2	1.5
Specialty Shops	60	50	40	2.0	3.0	4.0	5.0	7.5	10	.10	.20	.30	25	35	45	30	40	50	40	50	60	300	250	200	1.2	1.4	2.0

* Refrigeration loads are for entire application.
† Air quantities shown are for all-air systems.
‡ Includes other equipment loads expressed in watts/sq ft.
** Air quantities for heavy manufacturing areas are based on supplementary means to remove excessive heat.

APPENDIX 1

FINAL EXAMINATION

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Table 5-2a Surface Unit Conductances and Unit Resistances for Air[a]

		Surface Emittances											
		$\epsilon = 0.9$				$\epsilon = 0.2$				$\epsilon = 0.05$			
		h		*R*		*h*		*R*		*h*		*R*	
Position of Surface	Direction of Heat Flow	Btu / hr-ft^2-F	W / m^2-C	hr-ft^2-F / Btu	m^2-C / W	Btu / hr-ft^2-F	W / m^2-C	hr-ft^2-F / Btu	m^2-C / W	Btu / hr-ft^2-F	W / m^2-C	hr-ft^2-F / Btu	m^2-C / W
Still Air													
Horizontal	Upward	1.63	9.26	0.61	0.11	0.91	5.2	1.10	0.194	0.76	4.3	1.32	0.232
Sloping—45 degrees	Upward	1.60	9.09	0.62	0.11	0.88	5.0	1.14	0.200	0.73	4.1	1.37	0.241
Vertical	Horizontal	1.46	8.29	0.68	0.12	0.74	4.2	1.35	0.238	0.59	3.4	1.70	0.298
Sloping—45 degrees	Downward	1.32	7.50	0.76	0.13	0.60	3.4	1.67	0.294	0.45	2.6	2.22	0.391
Horizontal	Downward	1.08	6.13	0.92	0.16	0.37	2.1	2.70	0.476	0.22	1.3	4.55	0.800
Moving Air													
(any position) Wind is 15 mph or 6.7 m/s (for winter)	Any	6.0	34.0	0.17	0.029								
Wind is $7\frac{1}{2}$ mph or 3.4 m/s (for summer)	Any	4.0	22.7	0.25	0.044								

[a]Conductances are for surfaces of the stated emittance facing virtual blackbody surroundings at the same temperature as the ambient air. Values are based on a surface–air temperature difference of 10 F and for a surface temperature of 70 F.

Source: Adapted by permission from *ASHRAE Handbook, Fundamentals Volume*, 1989.

APPENDIX 2

FINAL EXAMINATION

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Table 5-2a Thermal Properties of Building and Insulating Materials at a Mean Temperature of 75 F (English Units) (*Continued*)

Material	Description	Density ρ	Thermal Conductivity k	Unit Conductance C	Unit Resistance: Per Inch Thickness $1/k$	Unit Resistance: For Thickness Listed $1/C$	Specific Heat
		$\frac{lbm}{ft^3}$	$\frac{Btu\text{-}in.}{ft^2\text{-}hr\text{-}F}$	$\frac{Btu}{hr\text{-}ft^2\text{-}F}$	$\frac{ft^2\text{-}hr\text{-}F}{Btu\text{-}in.}$	$\frac{hr\text{-}ft^2\text{-}F}{Btu}$	$\frac{Btu}{lbm\text{-}F}$
	Lightweight aggregate (expanded shale, clay slate or slag; pumice)						
	3 in. or 75 mm	—	—	0.79	—	1.27	
	4 in. or 100 mm	—	—	0.67	—	1.50	
	8 in. or 200 mm	—	—	0.50	—	2.00	
	12 in. or 300 mm	—	—	0.44	—	2.27	—
Plastering Materials	Cement plaster, sand, aggregate	116	5.0	—	0.20	—	—
	Gypsum plaster:						
	Lightweight aggregate						
	$\frac{1}{2}$ in. or 13 mm	45	—	3.12	—	0.32	—
	$\frac{5}{8}$ in. or 16 mm	45	—	2.67	—	0.39	—
	Lightweight aggregate on metal lath						
	$\frac{3}{4}$ in. or 20 mm	—	—	2.13	—	0.47	—
Roofing	Asbestos-cement shingles	120	—	4.76	—	0.21	—
	Asphalt roll roofing	70	—	6.50	—	0.15	—
	Asphalt shingles	70	—	2.27	—	0.44	—
	Built-in roofing						
	$\frac{3}{8}$ in. or 10 mm	70	—	3.00	—	0.33	0.35
	Slate, $\frac{1}{2}$ in. or 13 mm	—	—	20.00	—	0.05	—
	Wood shingles—plain or plastic film faced	—	—	1.06	—	0.94	0.31

APPENDIX 3

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Material	Description	Density ρ lbm/ft³	Thermal Conductivity k Btu-in./ft²-hr-F	Unit Conductance C Btu/hr ft²-F	Unit Resistance Per Inch Thickness $1/k$ ft²-hr-F/Btu-in.	Unit Resistance For Thickness Listed $1/C$ hr ft²-F/Btu	Specific Heat Btu/lbm F
Loose Fill	Mineral fiber—rock, slag, or glass						
	Approximately 3.75–5 in. or 75–125 mm	0.6–2.0	—	—	—	11	0.17
	Approximately 6.5–8.75 in. or 165–222 mm	0.6–2.0	—	—	—	19	0.17
	Approximately 7.5–10 in. or 191–254 mm	—	—	—	—	22	0.17
	Approximately 7¼ in. or 185 mm	—	—	—	—	30	0.17
	Silica aerogel	7.6	0.17	—	5.88	—	—
	Vermiculite (expanded)	7–8	0.47	—	2.13	—	—
Roof Insulation	Preformed, for use above deck						
	Approximately ½ in. or 13 mm	—	—	0.72	—	1.39	—
	Approximately 1 in. or 25 mm	—	—	0.36	—	2.78	—
	Approximately 2 in. or 50 mm	—	—	0.19	—	5.56	—
	Cellular glass	9	0.4	—	2.5	—	0.21
Masonry Materials	Lightweight aggregates including	200	5.2	—	0.19	—	—
Concretes	expanded shale, clay, or slate;	100	3.6	—	0.28	—	—
	expanded slags; cinders;	80	2.5	—	0.40	—	—
	pumice; vermiculite; also	40	1.15	—	0.86	—	—
	cellular concretes	20	0.70	—	1.43	—	—
	Sand and gravel or stone aggregate (not dried)	140	12.0	—	0.08	—	—
Masonry Units	Brick, common	120	5.0	—	0.20	—	—
	Brick, face	130	9.0	—	0.11	—	—
	Concrete blocks, three oval core—sand and gravel aggregate						
	4 in. or 100 mm	—	—	1.4	—	0.71	—
	8 in. or 200 mm	—	—	0.9	—	1.11	—
	12 in. or 300 mm	—	—	0.78	—	1.28	—

CONT APPENDIX 3

FINAL EXAMINATION

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VARIOUS FORMULA

$$U = 1 / \Sigma R$$

$$Rx = \Delta x / Kx$$

$$\Sigma R = Ro + \Delta X1/ K1 + \Delta X2/K2 + Ri$$

$$\dot{V}_{suction} = \dot{m} \times v$$

$$Q_c = \dot{m}(h_2 - h_3)$$

$$\eta_V = \frac{V_{suction}}{V_{swept}}$$

$$\eta_{eff} = \frac{\dot{m}(h_{2is} - h_1)}{W_{eff}}$$

$$\eta_{is} = \frac{(h_{2is} - h_1)}{h_2 - h_1}$$

$$COP = \frac{h_1 - h_4}{h_2 - h_1}$$

$$COP = \frac{Q_{in\ (evap)}}{W_{in\ (comp)}}$$