As the room volume is 40,000 cu ft, the air changes per hour will be 76,500/40,000 = 1.91 which is more than one air change.

Estimated Time of Maximum Cooling Load:

For this job, judgment indicates that the roof will make the greatest single contribution to the cooling load. Hence, the time of maximum cooling load probably will be the time of maximum heat gain through the roof. From Table 9 the maximum temperature differential for a 2 in. gypsum roof of medium weight construction is 54 deg at 4:00 p.m., and 53 deg at 3:00 p.m. Examination of Table 13 (40 deg N Latitude) shows that solar heat gain through glass on the south wall is 18 Btu per (hr) (sq ft) at 4:00 p.m., and 42 Btu at 3:00 p.m. This indicates that the maximum cooling load occurs at approximately 3:00 p.m. Therefore make load calculations at 3:00 p.m. sun time. (This may be slightly different from 3:00 p.m. local time.) In some cases, there would be no clear-cut evidence of this nature, and consequently, it would be necessary to estimate the load for several successive times, and then to select the maximum.

Heat Gain Through Outer Wall and Roof Areas:

From Table 10 the temperature differential for the south wall (8 in. concrete block with 4 in. brick veneer) may be about the same as a 12 in. brick which is 6 deg at 3:00 p.m. for a dark colored wall. From the same table, the temperature differential for the east wall (8 in. concrete block with plaster) will be 11 deg at 3:00 p.m. for a *light colored* wall (interpolating between 2:00 and 4:00 p.m.). Likewise, the temperature differential for the north exposed wall (8 in. concrete block plus plaster) will be 3 deg at 3:00 p.m. (by interpolation) for a light wall.

The party wall of 13 in. brick on the west side and part of the north side may be treated as if it were an outside wall in the shade which has a temperature differential (from Table 10) of 2 deg.

For the door in north wall estimate $U = 0.59$ from Chapter 9, Table 10, No. 5A. The outdoor temperature at 3:00 p.m. is 95 F. Neglect time lag and any decrement factor. The temperature differential is $(t_p - t_i) = 95 - 80 = 15$ deg. The tabulation of the preceding values at 3:00 p.m. is given in the following table:

Section	Net Area Sq Ft	Temperature Differential F Deg	Heat Transmission Coefficient (U)	Heat Flow Rate per Hour Btu
Roof	4000	53	0.34	72,000
South Wall	405[a]	6	0.41	995
East Wall	765[a]	11	0.52	4,380
North Exposed Wall	170[a]	3	0.52	265
West & North Party Wall	1065[a]	2	0.26	550
Door in North Wall	35	15	0.59	310
Total				78,500

[a] Calculated from gross wall area, less windows and doors.

Heat Gain Through Glass Areas

In computing the load for 3:00 p.m., only the south windows and doors will be exposed to direct sunlight. Tables 13 and 14 will give the total heat gain from the glass areas. The window reveals will shade the south windows; the fraction of the window area receiving direct radiation is obtained from Equation 5 by substituting values as follows:

$$r_1 = s/l = 4/60;\ r_2 = 4/36;\ \beta = 45.5 \text{ deg, } \tan\beta = 1.02$$

$$\gamma = 74 \text{ deg, } \tan\gamma = 3.487,\ \cos\gamma = 0.276$$

$$G_t = 1 - \frac{4}{60}\left(\frac{1.02}{0.276}\right) - \frac{4}{36}(3.487) + \left(\frac{4}{60}\right)\left(\frac{4}{36}\right)\frac{(1.02)\,(3.487)}{0.276} = 0.462$$

The south doors will be considered entirely sunlit. The outdoor air temperature is 96 F at 3:00 p.m. From Table 24 the inside Venetian blind factor is 0.65. The

instantaneous heat gains due to transmitted direct and diffuse solar radiation, and from convection and radiation gain, are found in Tables 13 and 14 as listed below for the south facing doors and windows, the north facing windows and the ½ glass doors in the east wall. The gain through the solid portion of the east doors may be approximated by use of Fig. 3, since the wood panels have little heat capacity. From Table 4 the diffuse radiation value is taken as 18 Btu per (hr)(sq ft) from which $t_o + \alpha_o I_t / f_{ero}$ is found to be 98.2 for $\alpha = 0.7$ and $f_{ero} = 4.0$. From Fig. 3, $q = 27.0$ Btu per (hr)(sq ft). These heat gains are itemized in the following table (note that there are no corrections to Table 14 values since table is based on 80 F temperature, but Fig. 3 is based on 75 F room temperature).

Location	Area Sq Ft	Fraction Sunlit	Shade Factor	Trans Solar Gain Btu/(hr)(sq ft)	Conv and Rad Gain Btu/(hr)(sq ft)	Corr from 75F to 80F Indoor Temperature Btu/(hr)(sq ft)	Total Gain Btu/(hr)(sq ft)	Total Gain Btu/hr
South Windows	60	0.462	0.65	13	19	—	32	1920
South Doors	35	1.00	—	42	19	—	61	2135
East Doors Glass	18	—	—	14	17	—	31	560
East Doors Wood	18	—	—	—	27	—	22	395
North Windows	30	—	—	15	17	—	32	960
Total								5970

In some jobs it would be desirable to increase (or decrease) the instantaneous radiation heat gain by a load-lag factor. The reason for not doing so in this case is that the solar gain is of a low magnitude, and reference to the table indicates that 0.8 of the previous hour would not affect the results materially.

Heat Gain from Ventilation and Infiltration:

Since the necessary ventilation rate 1275 cfm is greater than one air change per hour, it will be satisfactory for determining the ventilation component of the heat gain.

Window infiltration can be taken as negligible since the windows do not open.

Door infiltration requires some judgment. Assume that for each person passing through the double doors, the infiltration will be 100 cu ft of outdoor air, see Chapter 10, Table 3. Assume that the outside doors will be used at the rate of 10 persons per hour and the inside doors at the rate of 30 persons per hour. Total infiltration will then be 40 × 100 = 4000 cfh or 67 cfm.

The design rate of entry of outside air is then:

$$Q = 1275 + 67 = 1342 \text{ cfm.}$$

The sensible, latent and total loads are determined from Equations 7, 8, and 9, respectively, at 3:00 p.m. (Table 8) $t_o = 95$, $t_i = 80$, $W_o = 0.0169$, $W_i = 0.0098$. All the air entering the room as infiltration becomes a part of the space load.

Infiltration (see Equations 7, 8, and 9):

$q_s = 67 \times 1.08\ (95-80) = 1085$ Btuh, sensible.

$q_e = 67 \times 4840\ (0.0169-0.0098) = 2300$ Btuh, latent.

$q_t = q_s + q_e = 1085 + 2300 = 3385$ Btuh, total.

Ventilation Air Taken through Cooling Unit Which Becomes a Part of the Space Load (see Equations 10 and 11):

$q_{si} = 1275 \times 1.08\ (95-80)\ (0.15) = 3{,}100$ Btuh, sensible.

$q_{ei} = 1275 \times 4840\ (0.0169-0.0098)\ (0.15) = 6{,}570$ Btuh, latent.