MEBS6006 Environmental Services 1
Exercise on 'Loading Estimation'

Consider a classroom having the following configuration and details. By using RTS Method, determine the total sensible and latent load of the classroom at 4pm (solar time) of a design day in July (July 21).

Size: 6m × 8m × 3m(H)
Population: 48 people (9am – 5pm) – no people other times
Window wall: 1 no. 8m × 3m(H) (others are internal walls)
Window area: 5 nos. 1.5m × 1m(H) – south facing, no shading, U = 1.8W/m$^2$K, clear glass
Roof: not required
Assume all walls are brick walls using Wall No. 11 in Table 16 (Wall Conduction Time Series)

Solar Intensity and Sol-air temperature are presented.
Design room temperature = 25°C, 50%rh

Step 1)
Conduction Heat Gain through external walls and roof

$$q_\theta = \sum_{j=0}^{23} c_j UA(t_{e,\theta-j\delta} - t_{rc})$$

$$q_\theta = c_0 UA(t_{e,\theta} - t_{rc}) + c_1 UA(t_{e,\theta-\delta} - t_{rc}) + c_2 UA(t_{e,\theta-2\delta} - t_{rc}) + \ldots + c_{23} UA(t_{e,\theta-23\delta} - t_{rc})$$

where

$q_\theta$ = hourly conductive heat gain, Btu/h (W), for the surface
$U$ = overall heat transfer coefficient for the surface, Btu/h·ft$^2$·°F(W/m$^2$·K)
$A$ = surface area, ft$^2$ (m$^2$)
$c_j$ = $j^{th}$ conduction time series factor
$t_{e,\theta-j\delta}$ = sol-air temperature, °F (°C), $j$ hours ago
$t_{rc}$ = presumed constant room air temperature, °F (°C)
$\theta$ = the current hour
$\delta$ = the time step (one hour)

U value = 0.571 W/m$^2$K
Area = 8m × 3m – 5 × 1.5m × 1m = 16.5m$^2$

Solar Intensity (W/m? for July 21, 22.3N Latitude, -114.2E Longitude, Time Zone: GMT+ Standard Time

Clearness Index: CN = 1, Ground Reflectance: rhog = 0.2

| Local Time | N | NE | E | SE | S | SW | W | NW | Horiz |
|---|---|---|---|---|---|---|---|---|---|
| 1.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 3.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 4.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 5.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 6.0 | 0.2 | 0.4 | 0.4 | 0.2 | 0.0 | 0.0 | 0.0 | 0.0 | 0.1 |
| 7.0 | 212.8 | 540.7 | 584.4 | 314.2 | 51.9 | 51.9 | 51.9 | 51.9 | 199.5 |
| 8.0 | 246.8 | 692.2 | 790.3 | 475.2 | 92.3 | 89.4 | 89.4 | 89.4 | 441.5 |
| 9.0 | 223.0 | 662.7 | 790.9 | 523.0 | 122.9 | 116.5 | 116.5 | 116.5 | 656.5 |
| 10.0 | 188.9 | 552.2 | 681.4 | 493.7 | 146.6 | 136.8 | 136.8 | 136.8 | 831.0 |
| 11.0 | 162.8 | 400.6 | 502.8 | 403.9 | 165.2 | 150.6 | 150.6 | 150.6 | 953.9 |
| 12.0 | 168.6 | 232.9 | 284.2 | 268.4 | 194.9 | 166.6 | 164.1 | 164.8 | 1017.0 |
| 13.0 | 168.5 | 164.5 | 163.7 | 166.3 | 194.6 | 272.1 | 289.8 | 237.0 | 1016.2 |
| 14.0 | 162.5 | 150.4 | 150.4 | 150.4 | 164.1 | 406.7 | 507.7 | 404.6 | 951.6 |
| 15.0 | 189.7 | 136.4 | 136.4 | 136.4 | 146.1 | 495.2 | 685.0 | 555.5 | 827.4 |
| 16.0 | 223.8 | 116.0 | 116.0 | 116.0 | 122.2 | 522.9 | 792.4 | 664.6 | 651.7 |
| 17.0 | 247.0 | 88.7 | 88.7 | 88.7 | 91.4 | 472.8 | 788.4 | 691.3 | 435.8 |
| 18.0 | 210.3 | 50.8 | 50.8 | 50.8 | 50.8 | 308.1 | 574.9 | 532.7 | 193.4 |
| 19.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 20.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 21.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 22.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 23.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 24.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |

Sol-Air Temperature (鈍) for July 21, 22.3N Latitude, -114.2E Longitude, Time Zone: GMT+ Standard Time

Clearness Index: CN = 1, Surface Color: alpha/ho = 0.05

| Local Time | Air Temp. | N | NE | E | SE | S | SW | W | NW | Horiz |
|---|---|---|---|---|---|---|---|---|---|---|
| 1.0 | 29.2 | 29.2 | 29.2 | 29.2 | 29.2 | 29.2 | 29.2 | 29.2 | 29.2 | 25.4 |
| 2.0 | 29.1 | 29.1 | 29.1 | 29.1 | 29.1 | 29.1 | 29.1 | 29.1 | 29.1 | 25.2 |
| 3.0 | 28.9 | 28.9 | 28.9 | 28.9 | 28.9 | 28.9 | 28.9 | 28.9 | 28.9 | 25.0 |
| 4.0 | 28.8 | 28.8 | 28.8 | 28.8 | 28.8 | 28.8 | 28.8 | 28.8 | 28.8 | 24.9 |
| 5.0 | 28.7 | 28.7 | 28.7 | 28.7 | 28.7 | 28.7 | 28.7 | 28.7 | 28.7 | 24.8 |
| 6.0 | 28.7 | 28.7 | 28.7 | 28.7 | 28.7 | 28.7 | 28.7 | 28.7 | 28.7 | 24.8 |
| 7.0 | 28.8 | 40.1 | 57.4 | 59.7 | 45.4 | 31.6 | 31.6 | 31.6 | 31.6 | 35.5 |
| 8.0 | 29.1 | 42.1 | 65.7 | 70.9 | 54.2 | 34.0 | 33.8 | 33.8 | 33.8 | 48.5 |
| 9.0 | 29.5 | 41.3 | 64.5 | 71.3 | 57.1 | 36.0 | 35.6 | 35.6 | 35.6 | 60.3 |
| 10.0 | 30.0 | 40.0 | 59.2 | 66.0 | 56.1 | 37.7 | 37.2 | 37.2 | 37.2 | 70.0 |
| 11.0 | 30.5 | 39.1 | 51.7 | 57.1 | 51.9 | 39.3 | 38.5 | 38.5 | 38.5 | 77.1 |
| 12.0 | 31.1 | 40.0 | 43.4 | 46.2 | 45.3 | 41.4 | 39.9 | 39.8 | 39.8 | 81.0 |
| 13.0 | 31.6 | 40.5 | 40.3 | 40.3 | 40.4 | 41.9 | 46.0 | 46.9 | 44.2 | 81.4 |
| 14.0 | 32.0 | 40.6 | 39.9 | 39.9 | 39.9 | 40.6 | 53.5 | 58.8 | 53.4 | 78.4 |
| 15.0 | 32.2 | 42.2 | 39.4 | 39.4 | 39.4 | 39.9 | 58.3 | 68.4 | 61.5 | 72.0 |
| 16.0 | 32.2 | 44.0 | 38.3 | 38.3 | 38.3 | 38.6 | 59.8 | 74.0 | 67.3 | 62.7 |
| 17.0 | 32.0 | 45.0 | 36.7 | 36.7 | 36.7 | 36.8 | 57.0 | 73.6 | 68.5 | 51.1 |
| 18.0 | 31.7 | 42.8 | 34.4 | 34.4 | 34.4 | 34.4 | 47.9 | 62.0 | 59.8 | 38.0 |
| 19.0 | 31.2 | 31.2 | 31.2 | 31.2 | 31.2 | 31.2 | 31.2 | 31.2 | 31.2 | 27.3 |
| 20.0 | 30.8 | 30.8 | 30.8 | 30.8 | 30.8 | 30.8 | 30.8 | 30.8 | 30.8 | 26.9 |
| 21.0 | 30.4 | 30.4 | 30.4 | 30.4 | 30.4 | 30.4 | 30.4 | 30.4 | 30.4 | 26.5 |
| 22.0 | 30.0 | 30.0 | 30.0 | 30.0 | 30.0 | 30.0 | 30.0 | 30.0 | 30.0 | 26.1 |
| 23.0 | 29.7 | 29.7 | 29.7 | 29.7 | 29.7 | 29.7 | 29.7 | 29.7 | 29.7 | 25.8 |
| 24.0 | 29.4 | 29.4 | 29.4 | 29.4 | 29.4 | 29.4 | 29.4 | 29.4 | 29.4 | 25.5 |

**Table 16 Wall Conduction Time Series (CTS)**

| | CURTAIN WALLS | | | STUD WALLS | | | | EIFS | | | BRICK WALLS | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Wall Number =** | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | **11** | **12** | **13** | **14** | **15** | **16** | **17** | **18** | **19** | **20** |
| **U-Factor, W/(m²·K)** | 0.428 | 0.429 | 0.428 | 0.419 | 0.417 | 0.406 | 0.413 | 0.668 | 0.305 | 0.524 | 0.571 | 0.377 | 0.283 | 0.581 | 0.348 | 0.628 | 0.702 | 0.514 | 0.581 | 0.389 |
| **Total *R*** | 2.3 | 2.3 | 2.3 | 2.4 | 2.4 | 2.5 | 2.4 | 1.5 | 3.3 | 1.9 | 1.7 | 2.7 | 3.5 | 1.7 | 2.9 | 1.6 | 1.4 | 1.9 | 1.7 | 2.6 |
| **Mass, kg/m²** | 31.0 | 20.9 | 80.0 | 25.5 | 84.6 | 25.6 | 66.7 | 36.6 | 38.3 | 130.9 | 214.1 | 214.7 | 215.8 | 290.6 | 304.0 | 371.7 | 391.5 | 469.3 | 892.2 | 665.1 |
| **Thermal Capacity, kJ/(m²·K)** | 30.7 | 20.4 | 67.5 | 24.5 | 73.6 | 32.7 | 61.3 | 36.7 | 38.8 | 120.5 | 177.8 | 177.8 | 177.8 | 239.1 | 253.5 | 320.9 | 312.7 | 388.4 | 784.9 | 580.5 |
| **Hour** | **Conduction Time Factors, %** | | | | | | | | | | | | | | | | | | | |
| 0 | 18 | 25 | 8 | 19 | 6 | 7 | 5 | 11 | 2 | | 0 | 0 | 0 | 1 | 2 | 2 | 1 | 3 | 4 | 3 |
| 1 | 58 | 57 | 45 | 59 | 42 | 44 | 41 | 50 | 25 | | 5 | 4 | 1 | 1 | 2 | 2 | 1 | 3 | 4 | 3 |
| 2 | 20 | 15 | 32 | 18 | 33 | 32 | 34 | 26 | 31 | | 14 | 13 | 7 | 2 | 2 | 2 | 3 | 3 | 4 | 3 |
| 3 | 4 | 3 | 11 | 3 | 13 | 12 | 13 | 9 | 20 | | 17 | 17 | 12 | 5 | 3 | 4 | 6 | 3 | 4 | 4 |
| 4 | 0 | 0 | 3 | 1 | 4 | 4 | 4 | 3 | 11 | | 15 | 15 | 13 | 8 | 5 | 5 | 7 | 3 | 4 | 4 |
| 5 | 0 | 0 | 1 | 0 | 1 | 1 | 2 | 1 | 5 | | 12 | 12 | 13 | 9 | 6 | 6 | 8 | 4 | 4 | 4 |
| 6 | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 0 | 3 | | 9 | 9 | 11 | 9 | 7 | 6 | 8 | 4 | 4 | 5 |
| 7 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | | 7 | 7 | 9 | 9 | 7 | 7 | 8 | 5 | 4 | 5 |
| 8 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | | 5 | 5 | 7 | 8 | 7 | 7 | 8 | 5 | 4 | 5 |
| 9 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | | 4 | 4 | 6 | 7 | 7 | 6 | 7 | 5 | 4 | 5 |
| 10 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | | 3 | 3 | 5 | 7 | 6 | 6 | 6 | 5 | 4 | 5 |
| 11 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | | 2 | 2 | 4 | 6 | 6 | 6 | 6 | 5 | 5 | 5 |
| 12 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | | 2 | 2 | 3 | 5 | 5 | 5 | 5 | 5 | 5 | 5 |
| 13 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | | 1 | 2 | 2 | 4 | 5 | 5 | 4 | 5 | 5 | 5 |
| 14 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | | 1 | 2 | 2 | 4 | 5 | 5 | 4 | 5 | 5 | 5 |
| 15 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | | 1 | 1 | 1 | 3 | 4 | 4 | 3 | 5 | 4 | 4 |
| 16 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | | 1 | 1 | 1 | 3 | 4 | 4 | 3 | 5 | 4 | 4 |
| 17 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | | 1 | 1 | 1 | 2 | 3 | 4 | 3 | 4 | 4 | 4 |
| 18 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | | 0 | 0 | 1 | 2 | 3 | 3 | 2 | 4 | 4 | 4 |
| 19 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | | 0 | 0 | 1 | 2 | 3 | 3 | 2 | 4 | 4 | 4 |
| 20 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | | 0 | 0 | 0 | 1 | 3 | 3 | 2 | 4 | 4 | 4 |
| 21 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | | 0 | 0 | 0 | 1 | 2 | 2 | 1 | 4 | 4 | 4 |
| 22 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | | 0 | 0 | 0 | 1 | 2 | 2 | 1 | 4 | 4 | 3 |
| 23 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 3 | 4 | 3 |
| **Total Percentage** | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |
| **Layer ID from outside to inside (see Table 19)** | F01 | F01 | F01 | F01 | F01 | F01 | F01 | F01 | F01 | F01 | F01 | F01 | F01 | F01 | F01 | F01 | F01 | F01 | F01 | F01 |
| | F09 | F08 | F10 | F08 | F10 | F11 | F07 | F06 | F06 | F05 | M01 | M01 | M01 | M01 | M01 | M01 | M01 | M01 | M01 | M01 |
| | F04 | F04 | F04 | G03 | G03 | G02 | G03 | I01 | I01 | I01 | F04 | F04 | F04 | F04 | F04 | F04 | F04 | F04 | F04 | F04 |
| | I02 | I02 | I02 | I04 | I04 | I04 | I04 | G03 | G03 | G03 | I01 | G03 | I01 | I01 | M03 | I01 | I01 | I01 | I01 | M15 |
| | F04 | F04 | F04 | G01 | G01 | G04 | G01 | F04 | I04 | M03 | G03 | I04 | G03 | M03 | I04 | M05 | M01 | M13 | M16 | I04 |
| | G01 | G01 | G01 | F02 | F02 | F02 | F02 | G01 | G01 | F04 | F04 | G01 | I04 | F02 | G01 | G01 | F02 | F04 | F04 | G01 |
| | F02 | F02 | F02 | 0 | 0 | 0 | 0 | F02 | F02 | G01 | G01 | F02 | G01 | 0 | F02 | F02 | 0 | G01 | G01 | F02 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | F02 | F02 | 0 | F02 | 0 | 0 | 0 | 0 | F02 | F02 | 0 |

**Wall Number Description**

1. Spandrel glass, insulation board, gyp board
2. Metal wall panel, insulation board, gyp board
3. 25 mm stone, insulation board, gyp board
4. Metal wall panel, sheathing, batt insulation, gyp board
5. 25 mm stone, sheathing, batt insulation, gyp board
6. Wood siding, sheathing, batt insulation, 13 mm wood
7. 25 mm stucco, sheathing, batt insulation, gyp board
8. EIFS finish, insulation board, sheathing, gyp board
9. EIFS finish, insulation board, sheathing, batt insulation, gyp board
10. EIFS finish, insulation board, sheathing, 200 mm LW CMU, gyp board
11. Brick, insulation board, sheathing, gyp board
12. Brick, sheathing, batt insulation, gyp board
13. Brick, insulation board, sheathing, batt insulation, gyp board
14. Brick, insulation board, 200 mm LW CMU
15. Brick, 200 mm LW CMU, batt insulation, gyp board
16. Brick, insulation board, 200 mm HW CMU, gyp board
17. Brick, insulation board, brick
18. Brick, insulation board, 200 mm LW concrete, gyp board
19. Brick, insulation board, 300 mm HW concrete, gyp board
20. Brick, 200 mm HW concrete, batt insulation, gyp board

The calculation is best computed using an excel spreadsheet

| time | Hour ago | c | U | A | $t_e$ | $t_{rc}$ | q |
|---|---|---|---|---|---|---|---|
| 16:00 | 0 | 0 | 0.571 | 16.5 | 38.6 | 25 | 0.00 |
| 15:00 | 1 | 5 | 0.571 | 16.5 | 39.9 | 25 | 7.02 |
| 14:00 | 2 | 14 | 0.571 | 16.5 | 40.6 | 25 | 20.58 |
| 13:00 | 3 | 17 | 0.571 | 16.5 | 41.9 | 25 | 27.07 |
| 12:00 | 4 | 15 | 0.571 | 16.5 | 41.4 | 25 | 23.18 |
| 11:00 | 5 | 12 | 0.571 | 16.5 | 39.3 | 25 | 16.17 |
| 10:00 | 6 | 9 | 0.571 | 16.5 | 37.7 | 25 | 10.77 |
| 9:00 | 7 | 7 | 0.571 | 16.5 | 36.0 | 25 | 7.25 |
| 8:00 | 8 | 5 | 0.571 | 16.5 | 34.0 | 25 | 4.24 |
| 7:00 | 9 | 4 | 0.571 | 16.5 | 31.6 | 25 | 2.49 |
| 6:00 | 10 | 3 | 0.571 | 16.5 | 28.7 | 25 | 1.05 |
| 5:00 | 11 | 2 | 0.571 | 16.5 | 28.7 | 25 | 0.70 |
| 4:00 | 12 | 2 | 0.571 | 16.5 | 28.8 | 25 | 0.72 |
| 3:00 | 13 | 1 | 0.571 | 16.5 | 28.9 | 25 | 0.37 |
| 2:00 | 14 | 1 | 0.571 | 16.5 | 29.1 | 25 | 0.39 |
| 1:00 | 15 | 1 | 0.571 | 16.5 | 29.2 | 25 | 0.40 |
| 0:00 | 16 | 1 | 0.571 | 16.5 | 29.4 | 25 | 0.41 |
| 23:00 | 17 | 1 | 0.571 | 16.5 | 29.7 | 25 | 0.44 |
| 22:00 | 18 | 0 | 0.571 | 16.5 | 30.0 | 25 | 0.00 |
| 21:00 | 19 | 0 | 0.571 | 16.5 | 30.4 | 25 | 0.00 |
| 20:00 | 20 | 0 | 0.571 | 16.5 | 30.8 | 25 | 0.00 |
| 19:00 | 21 | 0 | 0.571 | 16.5 | 31.2 | 25 | 0.00 |
| 18:00 | 22 | 0 | 0.571 | 16.5 | 34.4 | 25 | 0.00 |
| 17:00 | 23 | 0 | 0.571 | 16.5 | 36.8 | 25 | 0.00 |
| | | | | | | total | **123.22W** |

Step 2)
Fenestration Heat Gain is separated into parts: conductive heat gain and solar radiation

Conductive heat gain

$$q_\theta = UA(t_{o,\theta} - t_{rc}),$$

where

$q_\theta$ = hourly conductive heat gain, Btu/h (W), for the window;
$U$ = overall heat transfer coefficient for the window, Btu/h·ft$^2$·°F (W/m$^2$·K) as specified by the window manufacturer;
$A$ = window area—including frame, ft$^2$ (m$^2$);
$t_{o,}\theta$ = outdoor air temperature, °F (°C);
$t_{rc}$ = presumed constant room air temperature, °F (°C); and
$\theta$ = the current hour.

q = 1.8 W/m$^2$K × 7.5m$^2$ × (32.2 – 25)°C = **97.2W**
Solar Radiation

$$q_{SHG,D} = E_D A_{sunlit} \text{SHGC}(\theta) \quad (7.4a)$$

$$q_{SHG,d} = (E_d + E_r)A \cdot \text{SHGC}_{diffuse} \quad (7.4b)$$

$$q_{SHG} = q_{SHG,D} + q_{SHG,d} \quad (7.4c)$$

where

$q_{SHG,D}$ = direct (beam) solar heat gain, Btu/h·ft$^2$ (W/m$^2$)
$q_{SHG,d}$ = diffuse solar heat gain, Btu/h·ft$^2$ (W/m$^2$)
$q_{SHG}$ = total solar heat gain, Btu/h·ft$^2$ (W/m$^2$)
$E_D$ = incident direct (beam) irradiation, Btu/h·ft$^2$ (W/m$^2$)
$E_d$ = incident diffuse irradiation from sky, Btu/h·ft$^2$ (W/m$^2$)
$E_r$ = incident diffuse reflected irradiation, Btu/h·ft$^2$ (W/m$^2$)
SHGC ($\theta$) = angle-dependent SHGC determined from manufacturer's normal *SHGC* corrected by correction factors in Table 7.9 or 3.8
$\text{SHGC}_{diffuse}$ = the SHGC for diffuse irradiation, determined by multiplying the manufacturer's normal SHGC by the diffuse correction factor in Table 7.9 or 3.8
$A_{sunlit}$ = the unshaded area of the window, ft$^2$ (m$^2$)
$A$ = the total area of the window, including the frame, ft$^2$ (m$^2$)

$q_{SHG,D}$ = 122.2 W/m$^2$ × 7.5m$^2$ × (0.86× 0.488) = 384.6W

where $E_D$ = 122.2 W/m2, SHGC = Normal SHGC × Correction Factor

$q_{SHG,d}$ = (45.4+39.7) × 7.5 m$^2$ × (0.86× 0.907) = 497.8W

where $E_d$ = 45.4, $E_r$ = 39.7, SHGC = Normal SHGC × Correction Factor

$q_{SHG}$ = 384.6W + 497.8W = **882.4W**

Using the same approach, assume that the solar heat gains for the 24 hours are calculated. Using RTS to convert to cooling load, the Table 7.12 should be used.

| time | qSHG | RTF | |
|---|---|---|---|
| 16:00 | 882.40 | 52 | 458.85 |
| 15:00 | 1051.92 | 16 | 168.31 |
| 14:00 | 1181.52 | 8 | 94.52 |
| 13:00 | 1401.12 | 5 | 70.06 |
| 12:00 | 1403.28 | 3 | 42.10 |
| 11:00 | 1189.44 | 2 | 23.79 |
| 10:00 | 1055.52 | 2 | 21.11 |
| 9:00 | 884.88 | 1 | 8.85 |
| 8:00 | 664.56 | 1 | 6.65 |
| 7:00 | 373.68 | 1 | 3.74 |
| 6:00 | 0.00 | 1 | 0.00 |
| 5:00 | 0.00 | 1 | 0.00 |
| 4:00 | 0.00 | 1 | 0.00 |
| 3:00 | 0.00 | 1 | 0.00 |
| 2:00 | 0.00 | 1 | 0.00 |
| 1:00 | 0.00 | 1 | 0.00 |
| 0:00 | 0.00 | 1 | 0.00 |
| 23:00 | 0.00 | 1 | 0.00 |
| 22:00 | 0.00 | 1 | 0.00 |
| 21:00 | 0.00 | 0 | 0.00 |
| 20:00 | 0.00 | 0 | 0.00 |
| 19:00 | 0.00 | 0 | 0.00 |
| 18:00 | 365.76 | 0 | 0.00 |
| 17:00 | 658.08 | 0 | 0.00 |
| | | | **897.96W** |

**Table 7.12 Representative Solar RTS Values for Light to Heavy Construction**

| | Light | | | | | | Medium | | | | | | Heavy | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | With Carpet | | | No Carpet | | | With Carpet | | | No Carpet | | | With Carpet | | | No Carpet | | |
| % Glass | 10 | 50 | 90 | 10 | 50 | 90 | 10 | 50 | 90 | 10 | 50 | 90 | 10 | 50 | 90 | 10 | 50 | 90 |
| Hour | Radiant Time Factor, % | | | | | | | | | | | | | | | | | |
| 0 | 53 | 54 | 55 | 44 | 45 | 46 | 52 | 53 | 55 | 28 | 29 | 29 | 46 | 48 | 50 | 27 | 27 | 28 |
| 1 | 17 | 17 | 17 | 19 | 19 | 19 | 16 | 16 | 15 | 15 | 15 | 15 | 11 | 12 | 12 | 12 | 12 | 12 |
| 2 | 9 | 9 | 9 | 11 | 11 | 11 | 8 | 8 | 8 | 10 | 10 | 10 | 6 | 6 | 6 | 7 | 7 | 7 |
| 3 | 6 | 5 | 5 | 7 | 7 | 7 | 5 | 4 | 4 | 7 | 7 | 7 | 4 | 4 | 4 | 5 | 5 | 5 |
| 4 | 4 | 4 | 3 | 5 | 5 | 5 | 3 | 3 | 3 | 6 | 6 | 6 | 3 | 3 | 3 | 4 | 4 | 4 |
| 5 | 3 | 2 | 2 | 4 | 3 | 3 | 2 | 2 | 2 | 5 | 5 | 5 | 3 | 2 | 2 | 4 | 4 | 4 |
| 6 | 2 | 2 | 2 | 3 | 3 | 2 | 2 | 1 | 1 | 4 | 4 | 4 | 2 | 2 | 2 | 3 | 3 | 3 |
| 7 | 1 | 1 | 1 | 2 | 2 | 2 | 1 | 1 | 1 | 3 | 3 | 3 | 2 | 2 | 2 | 3 | 3 | 3 |
| 8 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 3 | 3 | 3 | 2 | 2 | 2 | 3 | 3 | 3 |
| 9 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 3 | 3 | 3 | 2 | 2 | 2 | 3 | 3 | 3 |
| 10 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 2 | 2 | 2 | 2 | 2 | 2 | 3 | 3 | 3 |
| 11 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 2 | 2 | 2 | 2 | 2 | 1 | 3 | 3 | 3 |
| 12 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 2 | 2 | 2 | 2 | 2 | 1 | 2 | 2 | 2 |
| 13 | 0 | 1 | 1 | 0 | 0 | 0 | 1 | 1 | 1 | 2 | 2 | 2 | 2 | 1 | 1 | 2 | 2 | 2 |
| 14 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 2 | 1 | 1 | 2 | 2 | 2 |
| 15 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 2 | 2 | 2 |
| 16 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 2 | 2 | 2 |
| 17 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 2 | 2 | 2 |
| 18 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 2 | 2 | 2 |
| 19 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 2 | 2 | 2 |
| 20 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 2 | 2 | 2 |
| 21 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | | 1 | 1 | 1 | 2 | 2 | 2 |
| 22 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | | 0 | 0 | 1 | 1 | 1 | 2 | 2 | 1 |
| 23 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 1 | 1 | 1 |
| | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |

Step 3)
Let Occupant heat gain = 65W (sensible), 30W(latent)
Occupant sensible (radiant) = 65W × 0.6 = 39W/person → 48 × 39W = 1872W
Occupant sensible (convective) = 65W × 0.4 = 26W/person → 48 × 26W = 1248W
Occupant latent = 48 × 30W = 1440W

Let lighting load = 15W/$m^2$ → 48$m^2$ × 15W/$m^2$ = 720W
Assume radiant fraction = 0.6, space fraction = 0.4
Lighting load (radiant) = 720W × 0.6 = 432W
Lighting load (convective) = 720W × 0.4 = 288W

Using RTS to convert to cooling load, the Table 7.11 should be used.
Total internal radiant load = 1872W + 432W = 2304W

| time | $Q_{sen}$ | RTF | |
|---|---|---|---|
| 16:00 | 2304 | 46 | 1059.84 |
| 15:00 | 2304 | 17 | 391.68 |
| 14:00 | 2304 | 9 | 207.36 |
| 13:00 | 2304 | 5 | 115.2 |
| 12:00 | 2304 | 3 | 69.12 |
| 11:00 | 2304 | 2 | 46.08 |
| 10:00 | 2304 | 2 | 46.08 |
| 9:00 | 2304 | 1 | 23.04 |
| 8:00 | 0 | 1 | 0 |
| 7:00 | 0 | 1 | 0 |
| 6:00 | 0 | 1 | 0 |
| 5:00 | 0 | 1 | 0 |
| 4:00 | 0 | 1 | 0 |
| 3:00 | 0 | 1 | 0 |
| 2:00 | 0 | 1 | 0 |
| 1:00 | 0 | 1 | 0 |
| 0:00 | 0 | 1 | 0 |
| 23:00 | 0 | 1 | 0 |
| 22:00 | 0 | 1 | 0 |
| 21:00 | 0 | 1 | 0 |
| 20:00 | 0 | 1 | 0 |
| 19:00 | 0 | 1 | 0 |
| 18:00 | 0 | 1 | 0 |
| 17:00 | 2304 | 0 | 0 |
| | | | **1958.4W** |

Step 4)
Ventilation load
Consider each person demands 8L/s of fresh air
Total fresh air = 48 × 8L/s = 384 L/s = 0.384$m^3$/s

Consider
outdoor air condition = 32.2°C DB, 26.7°C WB → w = 20.02 g/kg
indoor air condition = 25°C DB, 50%rh → w = 9.92 g/kg

sensible load = 1.23 × 0.384 × (32.2 – 25) = 3.4kW
latent load = 3010 × 0.384 × (20.02 – 9.92)/1000 = 11.7kW

**Table 7.11 Representative Nonsolar RTS Values for Light to Heavy Construction**

| | Light | | | | | | Medium | | | | | | Heavy | | | | | | Interior Zones | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | | | | | | | | | Light | | Medium | | Heavy | |
| | With Carpet | | | No Carpet | | | With Carpet | | | No Carpet | | | With Carpet | | | No Carpet | | | | | | | | |
| % Glass | 10 | 50 | 90 | 10 | 50 | 90 | 10 | 50 | 90 | 10 | 50 | 90 | 10 | 50 | 90 | 10 | 50 | 90 | With Carpet | No Carpet | With Carpet | No Carpet | With Carpet | No Carpet |
| Hour | Radiant Time Factor, % | | | | | | | | | | | | | | | | | | | | | | | |
| 0 | 47 | 50 | 53 | 41 | 44 | 44 | 46 | 49 | 52 | 31 | 33 | 36 | 34 | 38 | 42 | 22 | 25 | 29 | 46 | 41 | 45 | 30 | 33 | 22 |
| 1 | 19 | 18 | 17 | 20 | 19 | 19 | 17 | 17 | 16 | 16 | 16 | 15 | 9 | 9 | 9 | 9 | 9 | 9 | 19 | 20 | 18 | 17 | 9 | 9 |
| 2 | 11 | 10 | 9 | 12 | 11 | 11 | 9 | 9 | 8 | 11 | 10 | 10 | 6 | 6 | 5 | 6 | 6 | 6 | 11 | 12 | 10 | 11 | 6 | 6 |
| 3 | 6 | 6 | 6 | 7 | 7 | 7 | 5 | 5 | 4 | 7 | 7 | 7 | 5 | 4 | 4 | 5 | 5 | 5 | 7 | 8 | 6 | 8 | 5 | 5 |
| 4 | 4 | 4 | 4 | 5 | 5 | 5 | 3 | 3 | 3 | 6 | 5 | 5 | 4 | 4 | 4 | 5 | 5 | 4 | 4 | 5 | 4 | 6 | 4 | 5 |
| 5 | 3 | 3 | 2 | 4 | 3 | 3 | 2 | 2 | 2 | 4 | 4 | 4 | 4 | 3 | 3 | 4 | 4 | 4 | 3 | 4 | 2 | 4 | 4 | 4 |
| 6 | 2 | 2 | 2 | 3 | 3 | 3 | 2 | 2 | 2 | 4 | 4 | 3 | 3 | 3 | 3 | 4 | 4 | 4 | 2 | 3 | 2 | 4 | 3 | 4 |
| 7 | 2 | 1 | 1 | 2 | 2 | 2 | 1 | 1 | 1 | 3 | 3 | 3 | 3 | 3 | 3 | 4 | 4 | 4 | 2 | 2 | 1 | 3 | 3 | 4 |
| 8 | 1 | 1 | 1 | 2 | 1 | 1 | 1 | 1 | 1 | 3 | 3 | 2 | 3 | 3 | 3 | 4 | 3 | 3 | 1 | 2 | 1 | 3 | 3 | 4 |
| 9 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 2 | 2 | 2 | 3 | 3 | 2 | 3 | 3 | 3 | 1 | 1 | 1 | 2 | 3 | 3 |
| 10 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 2 | 2 | 2 | 3 | 2 | 2 | 3 | 3 | 3 | 1 | 1 | 1 | 2 | 3 | 3 |
| 11 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 2 | 2 | 2 | 2 | 2 | 2 | 3 | 3 | 3 | 1 | 1 | 1 | 2 | 3 | 3 |
| 12 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 2 | 2 | 2 | 2 | 3 | 3 | 3 | 1 | 0 | 1 | 1 | 2 | 3 |
| 13 | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 2 | 2 | 2 | 3 | 3 | 2 | 1 | 0 | 1 | 1 | 2 | 3 |
| 14 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 2 | 2 | 2 | 3 | 2 | 2 | 0 | 0 | 1 | 1 | 2 | 3 |
| 15 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 2 | 2 | 2 | 3 | 2 | 2 | 0 | 0 | 1 | 1 | 2 | 3 |
| 16 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 2 | 2 | 2 | 2 | 2 | 2 | 0 | 0 | 1 | 1 | 2 | 2 |
| 17 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 2 | 2 | 2 | 2 | 2 | 2 | 0 | 0 | 1 | 1 | 2 | 2 |
| 18 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 2 | 2 | 1 | 2 | 2 | 2 | 0 | 0 | 1 | 1 | 2 | 2 |
| 19 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 2 | 2 | 1 | 2 | 2 | 2 | 0 | 0 | 1 | 1 | 2 | 2 |
| 20 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 1 | 1 | 0 | 2 | 1 | 1 | 2 | 2 | 2 | 0 | 0 | 0 | 0 | 2 | 2 |
| 21 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 2 | 2 | 2 | 0 | 0 | 0 | 0 | 1 | 2 |
| 22 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 2 | 2 | 1 | 0 | 0 | 0 | 0 | 1 | 2 |
| 23 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 2 | 2 | 1 | 0 | 0 | 0 | 0 | 1 | 2 |
| | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |

Step 5)
Consolidation of Sensible and Latent Load

| | Sensible (W) | | Latent (W) |
|---|---|---|---|
| | Radiant | Convective | |
| Wall (CTS) | | 123 | |
| Fenestration | 898 | 97 | |
| Occupant | 1958 | 1248 | 1440 |
| Lighting | | 288 | |
| Ventilation | | 3400 | 11700 |
| Total | 8012 | | 13140 |