Window header: 2x4 wood ; 3.5 wood stud 16oc

Description

- ½-in. gypsum board
  Thermal conductivity – 1.11 Btu-in/h-ft^2-F
  Density – 50 lb/ft^3
  Specific Heat – 0.26 Btu/lb-F
- 3.5-in. R-11 fiberglass batts
  Thermal conductivity – 0.32 Btu-in/h-ft^2-F
  Density – 5.3 lb/ft^3
  Specific Heat – 0.23 Btu/lb-F
- 2x4 wood studs
  Thermal conductivity – 1.0 Btu-in/h-ft^2-F
  Density – 36 lb/ft^3
  Specific Heat – 0.39 Btu/lb-F
- ½-in. plywood
  Thermal conductivity – 0.8 Btu-in/h-ft^2-F
  Density – 34 lb/ft^3
  Specific Heat – 0.29 Btu/lb-F
- ½-in wood siding
  Thermal conductivity – 0.5 Btu-in/h-ft^2-F
  Density – 34 lb/ft^3
  Specific Heat – 0.30 Btu/lb-F

COMPUTATION RESULTS

Three-dimensional model

Table 4.1
Resistance, transmittance and capacitance of the wall

	IP		*SI*	
R-value	9.40385	ft^2 °F h/Btu	1.65508	m^2 K/W
R^{-1}	0.10634	Btu/h ft^2 °F	0.60420	W/m^2 K
Capacitance	3.41003	Btu/ft^2 °F	69.67994	kJ/m^2 K

Table 4.2
Dimensionless 3D z-transfer function coefficients

n	b_n	c_n	d_n
0	0.10141	5.05305	1.00000
1	0.16607	-7.80490	-0.99046
2	-0.01517	3.47950	0.27744
3	0.01302	-0.46234	-0.02166

$\Sigma\, c_n = 0.26532, \quad E_1 = 0.00000$

Table 4.3
3D response factors calculated with the help of the finite difference computer code HEATING 7.2 [Btu/h ft^2 °F]

n	X_n	Y_n
0	5.3733909E-01	1.0783379E-02
1	-2.9775634E-01	2.8339877E-02
2	-7.3988512E-02	2.3464192E-02
3	-2.8195244E-02	1.6995917E-02
4	-1.3849479E-02	1.1033893E-02
5	-7.6849687E-03	6.8352882E-03
6	-4.4796029E-03	4.1650998E-03
7	-2.6636727E-03	2.5267945E-03
8	-1.5985620E-03	1.5330477E-03
9	-9.6447430E-04	9.3167868E-04
10	-5.8410387E-04	5.6740272E-04
11	-3.5482133E-04	3.4628723E-04
12	-2.1610131E-04	2.1175691E-04
13	-1.3191457E-04	1.2972152E-04
14	-8.0686519E-05	7.9593309E-05
15	-4.9440816E-05	4.8905345E-05
16	-3.0342822E-05	3.0086951E-05
17	-1.8647931E-05	1.8530036E-05
18	-1.1474584E-05	1.1423306E-05
19	-7.0682168E-06	7.0481108E-06
20	-4.3580449E-06	4.3518398E-06
21	-2.6892508E-06	2.6887583E-06
22	-1.6606707E-06	1.6621631E-06
23	-1.0261445E-06	1.0280334E-06
24	-6.3441203E-07	6.3609972E-07
25	-3.9241126E-07	3.9373460E-07
26	-2.4282414E-07	2.4379314E-07
27	-1.5031391E-07	1.5099434E-07
28	-9.3077110E-08	9.3541712E-08
29	-5.7650780E-08	5.7961762E-08

Table 4.4
3D response factors ratio, dimensionless 3D response factors and transfer functions of the first order

n	X_n/X_{n-1}	Y_n/Y_{n-1}	$R*X_n$	$R*Y_n$	$R*X'_n$	$R*Y'_n$
0			5.05305	0.10141	5.05305	0.10141
1	-0.55413	2.62811	-2.80005	0.26650	-5.93048	0.20368
2	0.24849	0.82796	-0.69578	0.22065	1.03889	0.05555
3	0.38108	0.72433	-0.26514	0.15983	0.16590	0.02313
4	0.49120	0.64921	-0.13024	0.10376	0.03402	0.00475
5	0.55489	0.61948	-0.07227	0.06428	0.00842	-0.00000
6	0.58290	0.60935	-0.04213	0.03917	0.00265	-0.00065
7	0.59462	0.60666	-0.02505	0.02376	0.00105	-0.00050
8	0.60013	0.60672	-0.01503	0.01442	0.00049	-0.00030
9	0.60334	0.60773	-0.00907	0.00876	0.00024	-0.00017
10	0.60562	0.60901	-0.00549	0.00534	0.00013	-0.00009
11	0.60746	0.61030	-0.00334	0.00326	0.00007	-0.00005
12	0.60904	0.61151	-0.00203	0.00199	0.00003	-0.00003
13	0.61043	0.61260	-0.00124	0.00122	0.00002	-0.00001
14	0.61166	0.61357	-0.00076	0.00075	0.00001	-0.00001
15	0.61275	0.61444	-0.00046	0.00046	0.00001	
16	0.61372	0.61521	-0.00029	0.00028		
17	0.61457	0.61588	-0.00018	0.00017		
18	0.61533	0.61648	-0.00011	0.00011		
19	0.61599	0.61699	-0.00007	0.00007		
20	0.61657	0.61745	-0.00004	0.00004		
21	0.61708	0.61784	-0.00003	0.00003		
22	0.61752	0.61819	-0.00002	0.00002		
23	0.61791	0.61849	-0.00001	0.00001		
24	0.61825	0.61875	-0.00001	0.00001		
25	0.61854	0.61898				
26	0.61880	0.61918				
27	0.61902	0.61935				
28	0.61922	0.61950				
29	0.61939	0.61964				

$\alpha = 0.61951$, $\tau_1 = 2.08845$

Equivalent wall model: 3 layers plane wall

Table 4.5
Structure factors and time constants

Structure factors		*Time constants [h]*	
φ_{ii}	0.20775	$R \cdot C \cdot \varphi_{ii}$	6.662
φ_{ie}	0.08353	$R \cdot C \cdot \varphi_{ie}$	2.679
φ_{ee}	0.62519	$R \cdot C \cdot \varphi_{ee}$	20.048
		$R \cdot C$	32.067

Table 4.6a
Thermophysical properties of the equivalent wall - IP units

Layer *N*	R_n Ft^2-°F-h/Btu	C_n Btu/ft^2-°F	l_n in	k_n Btu-in/h-ft^2-°F	ρ_n lb/ft^3	c_{pn} Btu/lb-°F
1	1.99222	0.62500	1	0.502	30	0.25
2	6.94802	0.92834	3	0.432	14.85	0.25
3	0.46361	1.85669	1	2.157	89.12	0.25

Table 4.6b
Thermophysical properties of the equivalent wall - SI units

Layer *N*	R_n m^2K/W	C_n kJ/ m^2 K	l_n m	k_n W/mK	ρ_n kg/m^3	c_{pn} kJ/kgK
1	0.35063	12.77112	0.025	0.072	480	1.048
2	1.22285	18.96961	0.076	0.062	237.66	1.048
3	0.08159	37.93922	0.025	0.311	1425.94	1.048

Table 4.7
Dimensionless z-transfer function coefficients and first time constants for the equivalent wall

n	b_n	c_n	d_n	τ_n
0	0.00631	5.79038	1.00000	
1	0.18709	-7.28938	-0.61032	1.335
2	0.23232	2.09824	0.06829	0.448
3	0.03035	-0.14500	-0.00155	0.282
4	0.00035	0.00220		0.148

$\Sigma\, c_n = 0.45642$, $\alpha = 0.47279$

Table 4.8
Response factors for the equivalent wall [Btu/h ft^2 °F]

n	X_n	Y_n
0	6.157454E-01	6.713637E-04
1	-3.993492E-01	2.030458E-02
2	-6.265150E-02	3.705122E-02
3	-2.543385E-02	2.445492E-02
4	-1.162940E-02	1.246397E-02
5	-5.457291E-03	5.994341E-03
6	-2.575792E-03	2.845101E-03
7	-1.217341E-03	1.346324E-03
8	-5.754959E-04	6.366559E-04
9	-2.720832E-04	3.010181E-04
10	-1.286375E-04	1.423197E-04
11	-6.081840E-05	6.728743E-05
12	-2.875430E-05	3.181281E-05
13	-1.359473E-05	1.504076E-05
14	-6.427448E-06	7.111119E-06
15	-3.038830E-06	3.362062E-06
16	-1.436727E-06	1.589548E-06
17	-6.792697E-07	7.515219E-07
18	-3.211516E-07	3.553116E-07
19	-1.518371E-07	1.679877E-07
20	-7.178703E-08	7.942280E-08
21	-3.394015E-08	3.755028E-08
22	-1.604655E-08	1.775338E-08
23	-7.586643E-09	8.393613E-09
24	-3.586885E-09	3.968413E-09
25	-1.695842E-09	1.876225E-09
26	-8.017766E-10	8.870592E-10
27	-3.790715E-10	4.193923E-10
28	-1.792211E-10	1.982844E-10
29	-8.473384E-11	9.374676E-11

Frequency response for the three-dimensional model and equivalent wall; dimensionless amplitude and phase angle

Table 4.9a
3-D model

	Transmittance		*Admittance*	
period	amplitude	phase angle	amplitude	phase angle
48	0.98	-19°	1.41	37°
24	0.88	-37°	2.15	45°
12	0.63	-64°	3.43	44°
6	0.30	-94°	5.14	34°

Table 4.9b
Equivalent wall

	Transmittance		*Admittance*	
period	amplitude	phase angle	amplitude	phase angle
48	0.98	-20°	1.39	38°
24	0.93	-39°	2.12	50°
12	0.79	-75°	3.51	53°
6	0.49	-133°	5.44	50°