CH EN 3453 – Heat Transfer

Radiation: Gray Surfaces

Sections 12.5 to 12.8

Reminders…

- Homework #10 due Friday
  - Help session 4:30 today in MEB 3235
- Final draft report due Friday
  - Email to report@chen3453.com in Microsoft Word format
  - Name the file "Lastname_Firstname.docx"
    - Can also be in .doc format
  - For the subject, write
    "Lastname Firstname - Heat Transfer Draft Report"
  - Send by 8:00 PM Friday
- Midterm #2 can be picked up in ChE office

Review - Problem 12.32

- What is the total emissivity of an object with the spectral emissivity shown below?

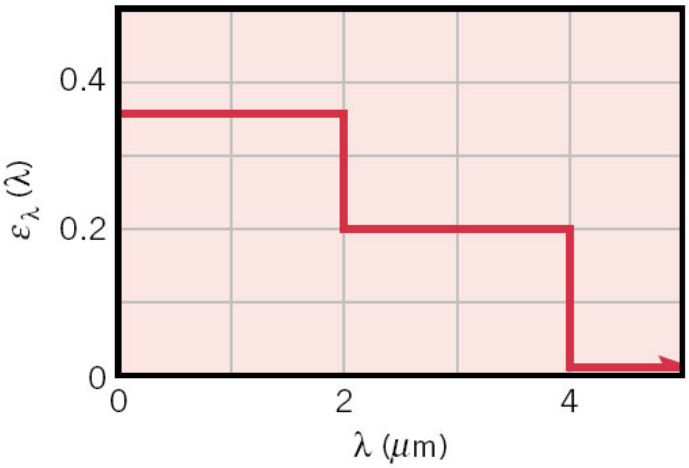


TABLE 12.1 Blackbody Radiation Functions

λT (μm · K)	$F_{(0\to\lambda)}$	$I_{\lambda,b}(\lambda,T)/\sigma T^5$ (μm · K · sr)$^{-1}$	$\frac{I_{\lambda,b}(\lambda,T)}{I_{\lambda,b}(\lambda_{max},T)}$
200	0.000000	0.375034×10^{-27}	0.000000
400	0.000000	0.490335×10^{-13}	0.000000
600	0.000000	0.104046×10^{-8}	0.000014
800	0.000016	0.991126×10^{-7}	0.001372
1,000	0.000321	0.118505×10^{-5}	0.016406
1,200	0.002134	0.523927×10^{-5}	0.072534
1,400	0.007790	0.134411×10^{-4}	0.186082
1,600	0.019718	0.249130	0.344904
1,800	0.039341	0.375568	0.519949
2,000	0.066728	0.493432	0.683123
2,200	0.100888	0.589649×10^{-4}	0.816329
2,400	0.140256	0.658866	0.912155
2,600	0.183120	0.701292	0.970891
2,800	0.227897	0.720239	0.997123
2,898	0.250108	0.722318×10^{-4}	1.000000
3,000	0.273232	0.720254×10^{-4}	0.997143
3,200	0.318102	0.705974	0.977373
3,400	0.361735	0.681544	0.943551
3,600	0.403607	0.650396	0.900429
3,800	0.443382	0.615225×10^{-4}	0.851737
4,000	0.480877	0.578064	0.800291
4,200	0.516014	0.540394	0.748139
4,400	0.548796	0.503253	0.696720
4,600	0.579280	0.467343	0.647004
4,800	0.607559	0.433109	0.599610
5,000	0.633747	0.400813	0.554898
5,200	0.658970	0.370580×10^{-4}	0.513043
5,400	0.680360	0.342445	0.474092
5,600	0.701046	0.316376	0.438002
5,800	0.720158	0.292301	0.404671
6,000	0.737818	0.270121	0.373965
6,200	0.754140	0.249723×10^{-4}	0.345724
6,400	0.769234	0.230985	0.319783
6,600	0.783199	0.213786	0.295973
6,800	0.796129	0.198008	0.274128
7,000	0.808109	0.183534	0.254090
7,200	0.819217	0.170256×10^{-4}	0.235708
7,400	0.829527	0.158073	0.218842
7,600	0.839102	0.146891	0.203360
7,800	0.848005	0.136621	0.189143
8,000	0.856288	0.127185	0.176079
8,500	0.874608	0.106772×10^{-4}	0.147819
9,000	0.890029	0.901463×10^{-5}	0.124801

TABLE 12.1 *Continued*

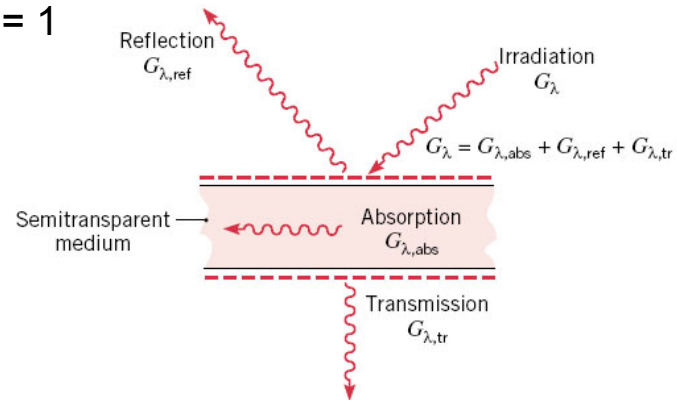
λT (μm · K)	$F_{(0\to\lambda)}$	$I_{\lambda,b}(\lambda,T)/\sigma T^5$ (μm · K · sr)$^{-1}$	$\frac{I_{\lambda,b}(\lambda,T)}{I_{\lambda,b}(\lambda_{max},T)}$
9,500	0.903085	0.765338	0.105956
10,000	0.914199	0.653279×10^{-5}	0.090442
10,500	0.923710	0.560522	0.077600
11,000	0.931890	0.483321	0.066913
11,500	0.939959	0.418725	0.057970
12,000	0.945098	0.364394×10^{-5}	0.050448
13,000	0.955139	0.279457	0.038689
14,000	0.962898	0.217641	0.030131
15,000	0.969981	0.171866×10^{-5}	0.023794
16,000	0.973814	0.137429	0.019026
18,000	0.980860	0.908240×10^{-6}	0.012574
20,000	0.985602	0.623310	0.008629
25,000	0.992215	0.276474	0.003828
30,000	0.995340	0.140469×10^{-6}	0.001945
40,000	0.997967	0.473891×10^{-7}	0.000656
50,000	0.998953	0.201605	0.000279
75,000	0.999713	0.418597×10^{-8}	0.000058
100,000	0.999905	0.135752	0.000019

Radiation Transfer Types

- Emission (*E*)
  - Associated with energy transfer due to surface temperature
- Irradiation (G)
  - Radiation incident onto a surface
  - Irradiation can have three fates:
    - Absorption by the surface
      (α = absorptivity = fraction of *G* absorbed)
    - Reflection by the surface
      (ρ = reflectivity = fraction of
    - Transmission through the material
      (τ = transmissivity = fraction transmitted)

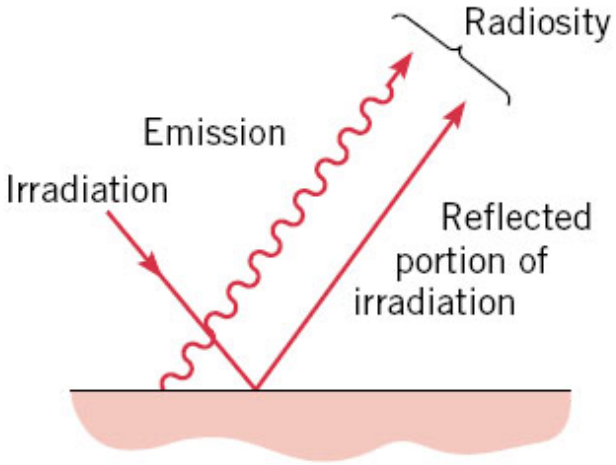
Irradiation onto a Surface

- Irradiation can have three fates:
  - Absorption by the surface
    (α = absorptivity = fraction of *G* absorbed)
  - Reflection by the surface
    (ρ = reflectivity = fraction of *G* reflected)
  - Transmission through the material
    (τ = transmissivity = fraction of *G* transmitted)
- Sum of $\alpha + \rho + \tau = 1$



Radiosity (J)

- Total radiation leaving a surface.
- Sum of emission plus reflected portion of irradiation.



Example: Problem 12.43

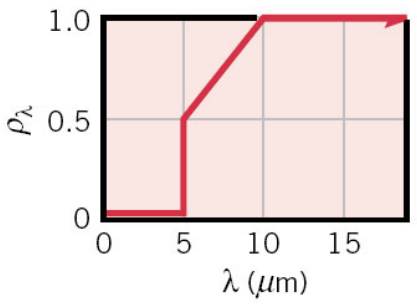
An opaque surface with the prescribed spectral, hemispherical reflectivity distribution is subjected to the spectral irradiation shown.

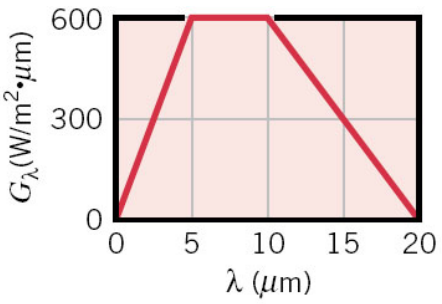
(a) Sketch the spectral absorptivity distribution

(b) Determine the total irradiation on the surface

(c) Determine the radiant flux that is absorbed by the surface

(d) What is the total absorptivity of this surface?





Gray Surface Behavior

Irradiation:

Emission:

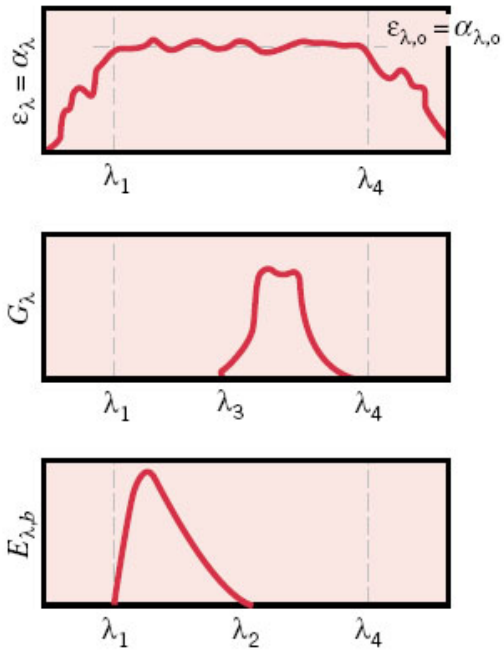
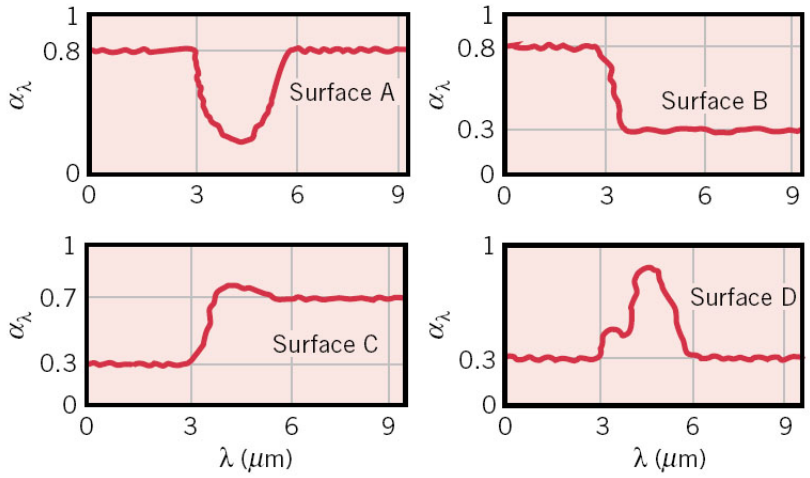


FIGURE 12.26

Example: Problem 12.61

Four diffuse surfaces having spectral characteristics shown are at 300K and are exposed to solar radiation. Which of the surfaces may be approximated as being gray?



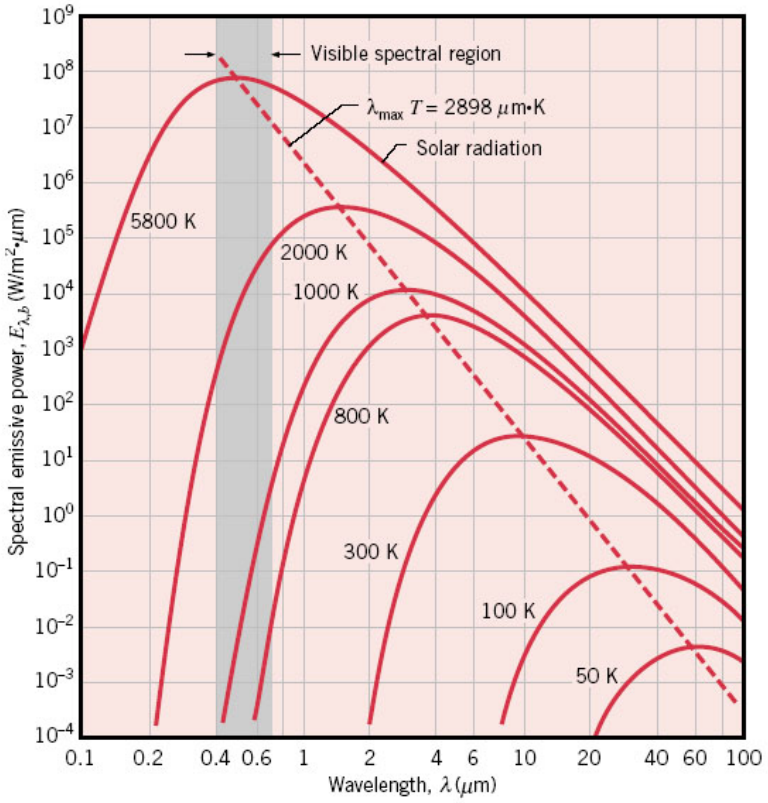


FIGURE 12.12 Spectral blackbody emissive power.