**Manual for Chapter – 11**

**11A.1 Unsteady-state heat conduction in an iron sphere.**

1. The thermal diffusivity of the sphere is given by Eq. 8.1-8:
2. The center temperature is to be 53°C; hence

Then, from Fig. 12.1-3, , and

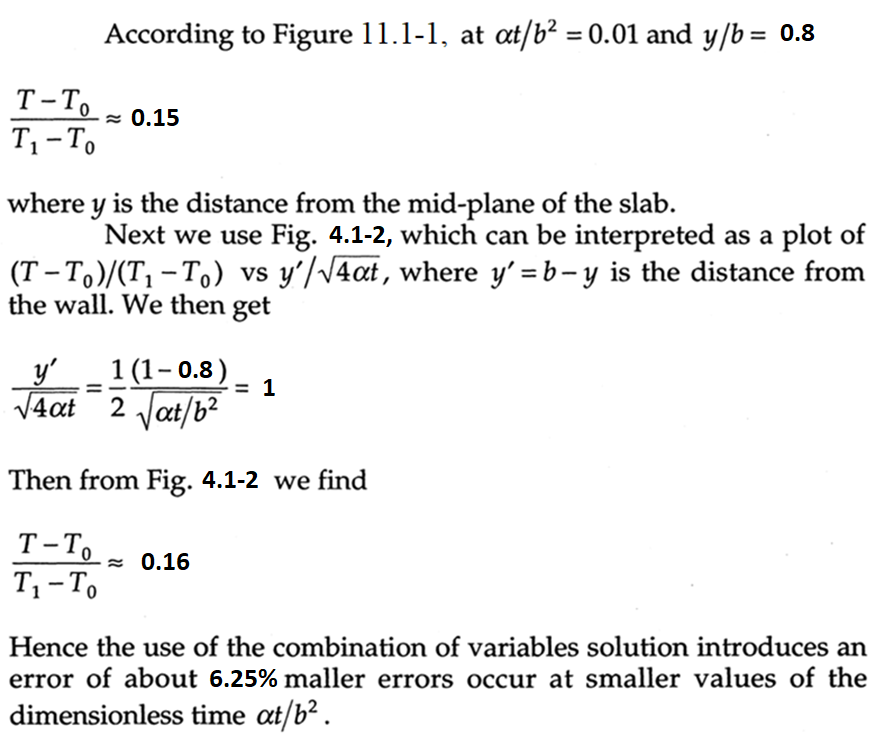
1. By equating the dimensionless times, we get

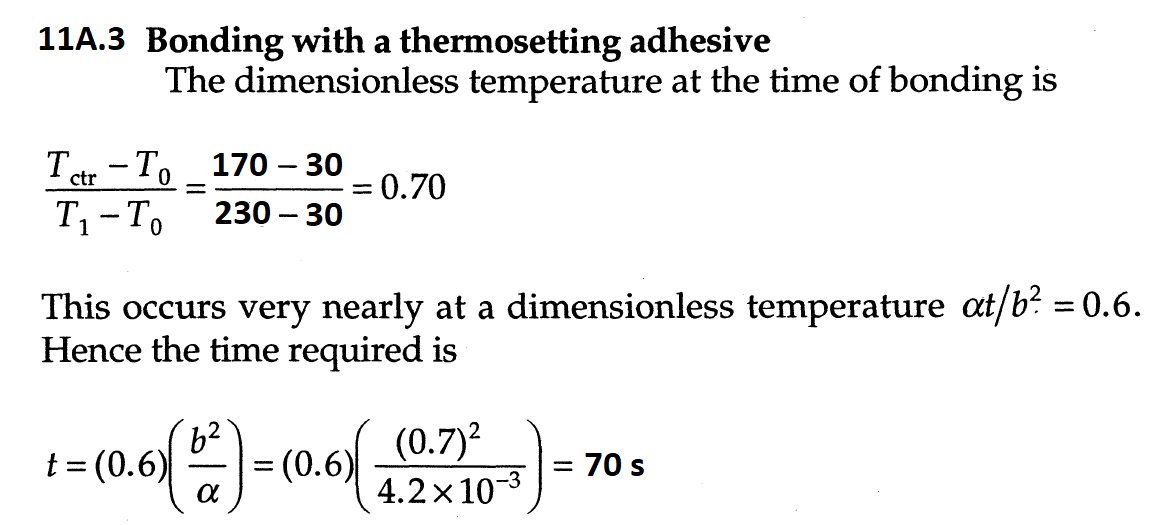


**or**

1. The partial differential equation from which Fig. 11.3-3 was constructed is

**11A.2 Comparison of the two slabs for short times.**

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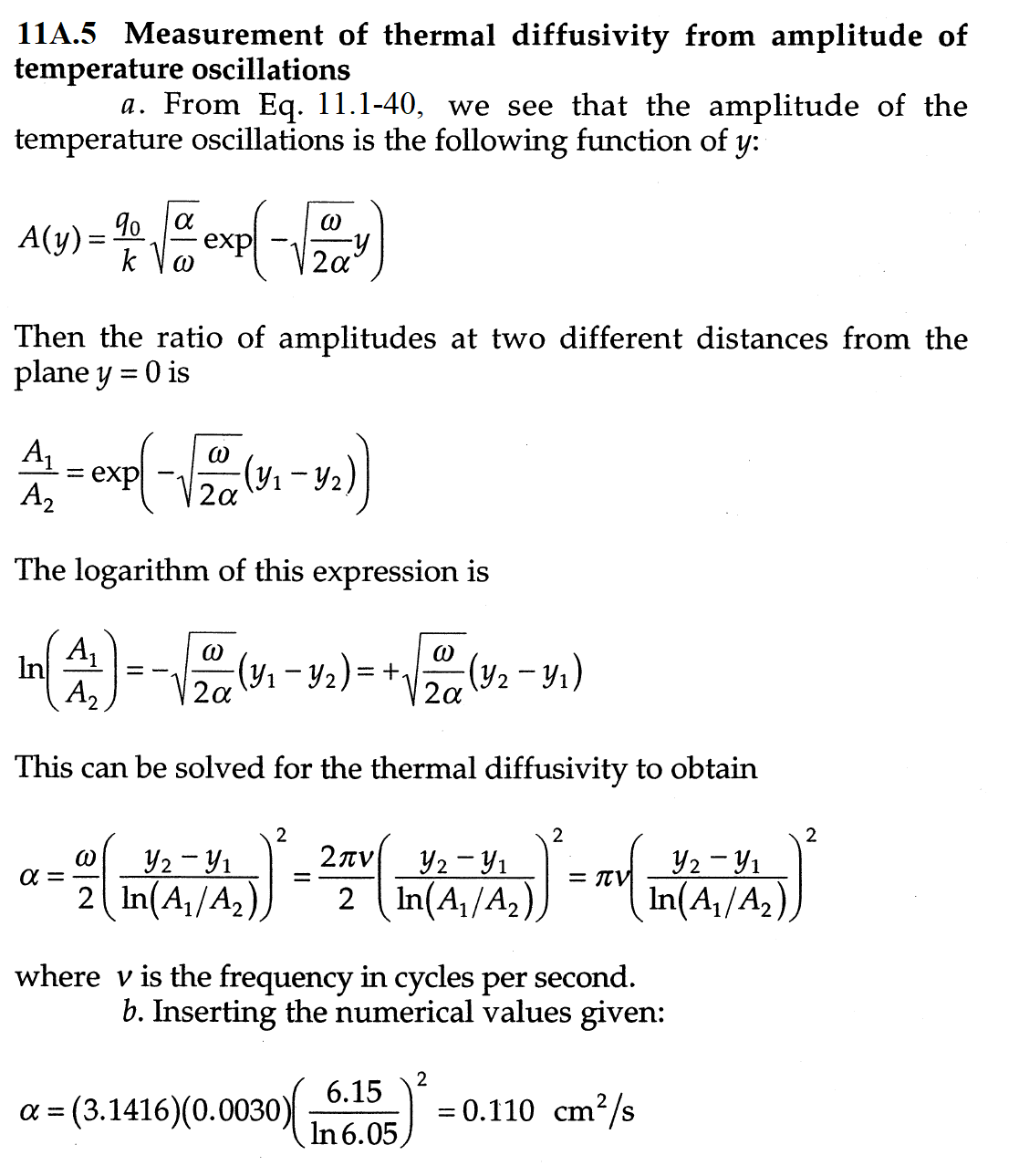
**11A.4. Quenching of a steel billet.**

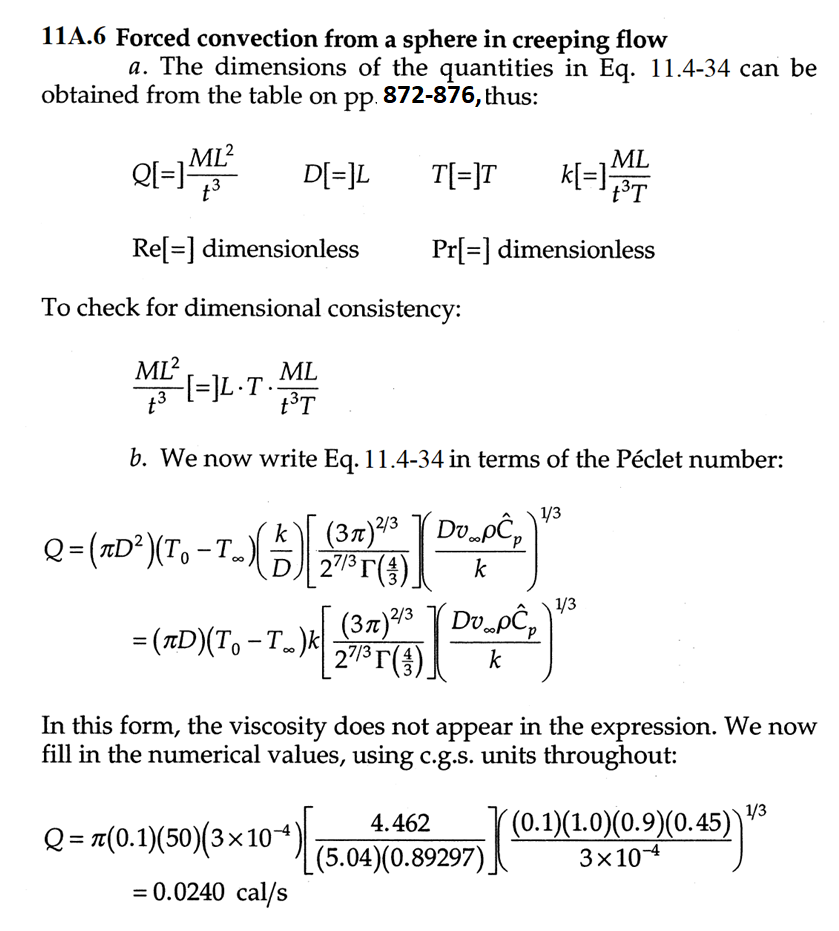
The thermal diffusivity of the steel billet is

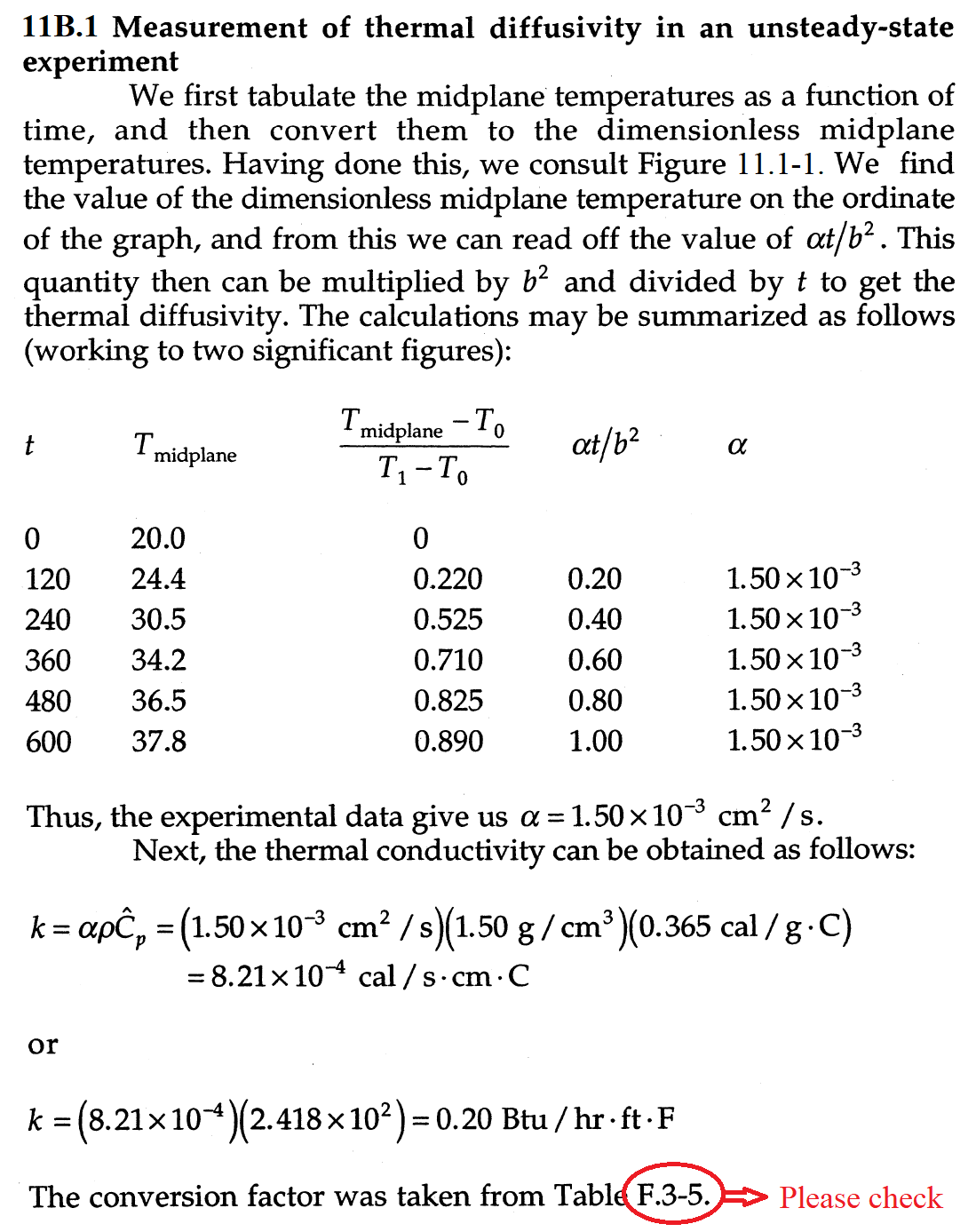
The dimensionless time is then

From Fig. 11.1-2, the dimensionless centre-line temperature is about 0.31. Therefore

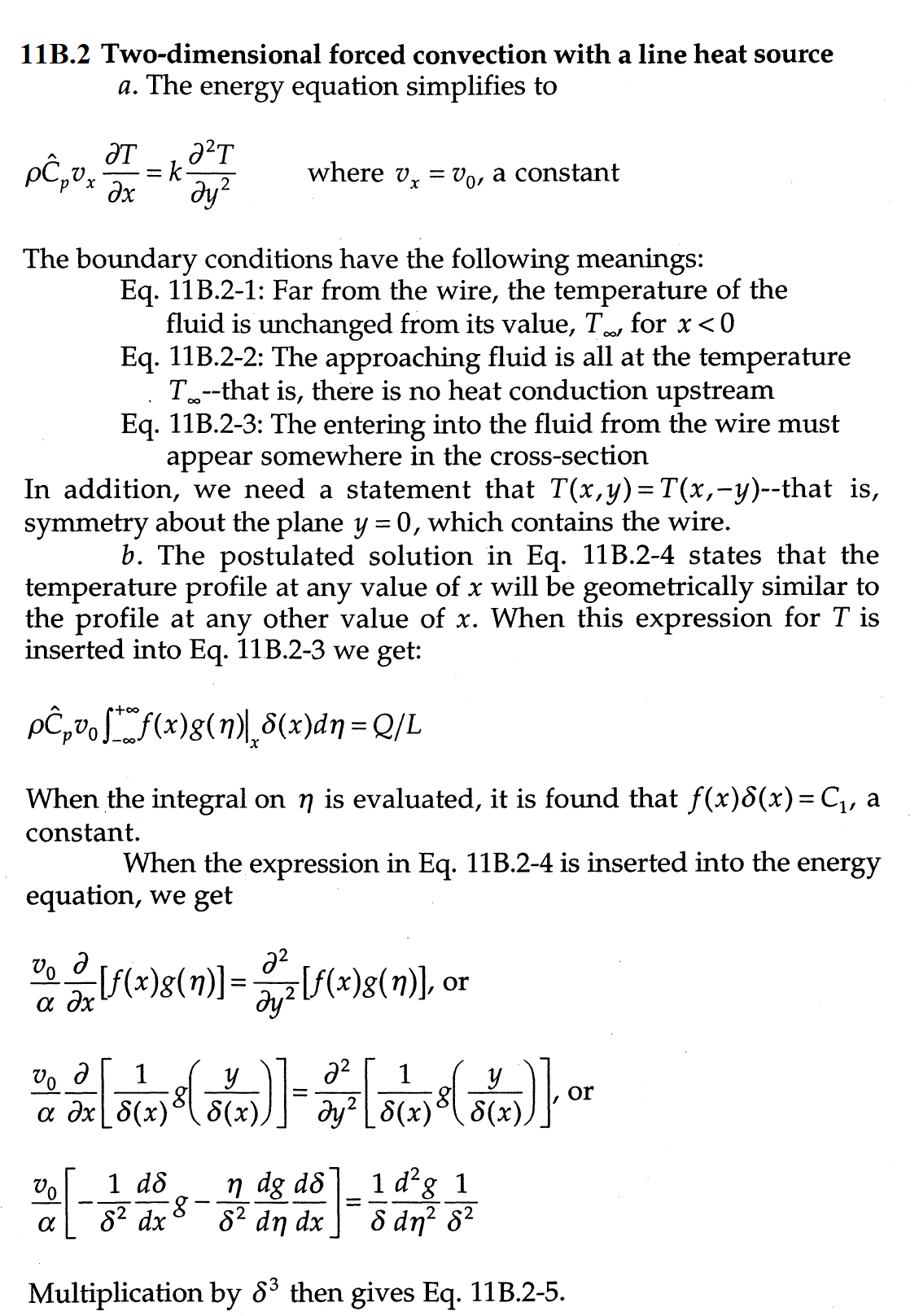
*T*centre = 0.31 (*T*1 -T0 ) + T0 = 0.31 (95 - 535) + 535 ≈ 399 °C

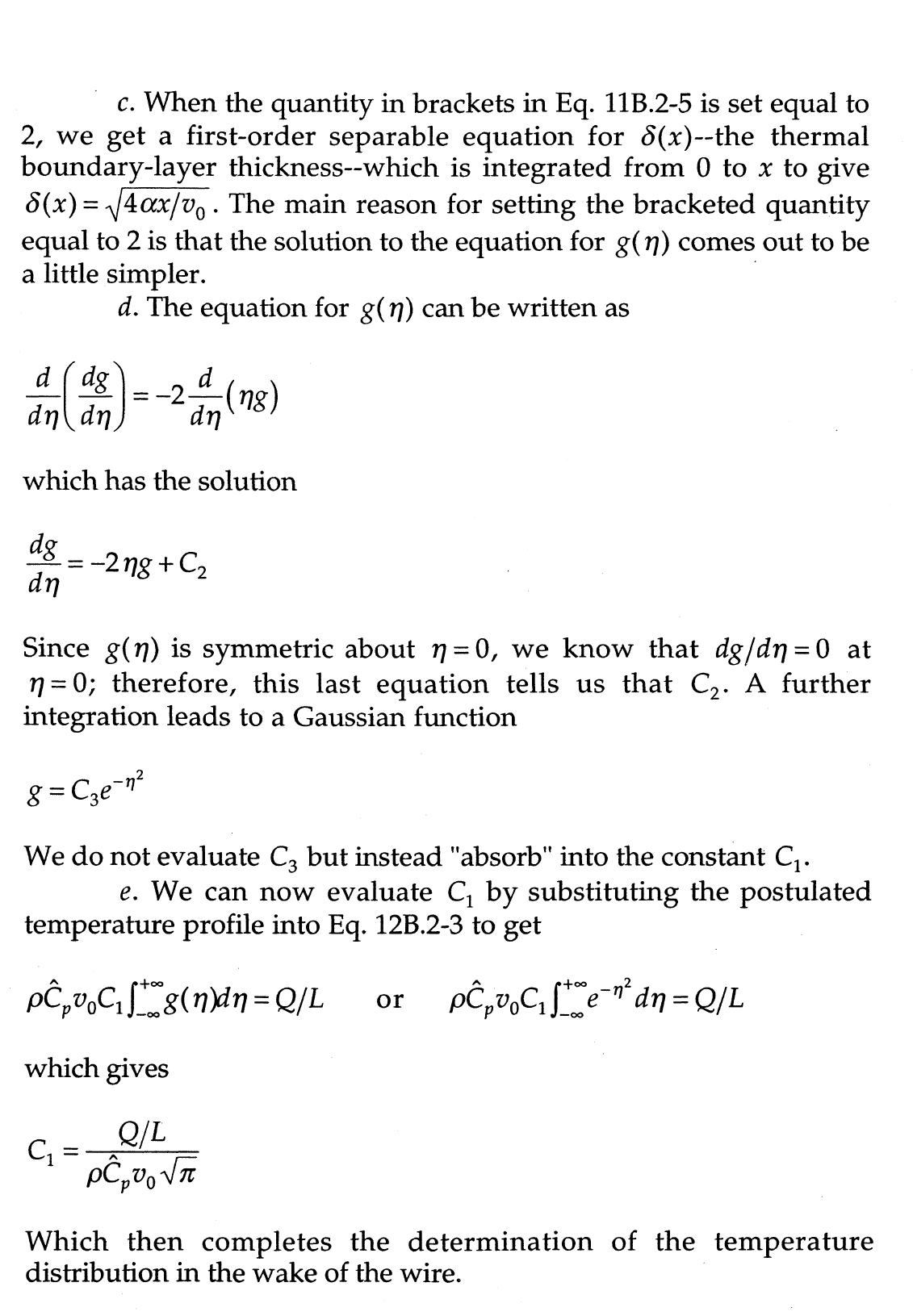


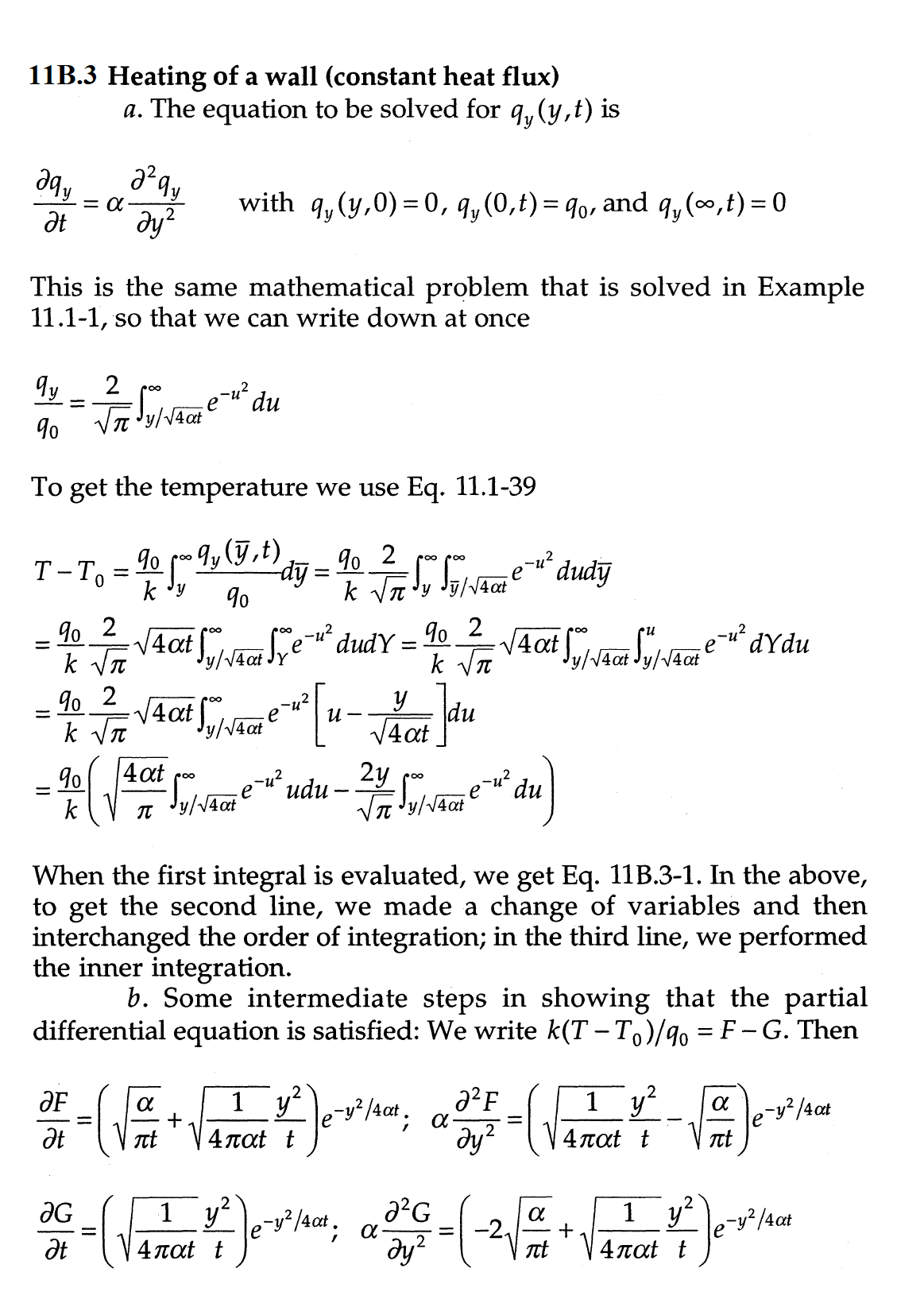


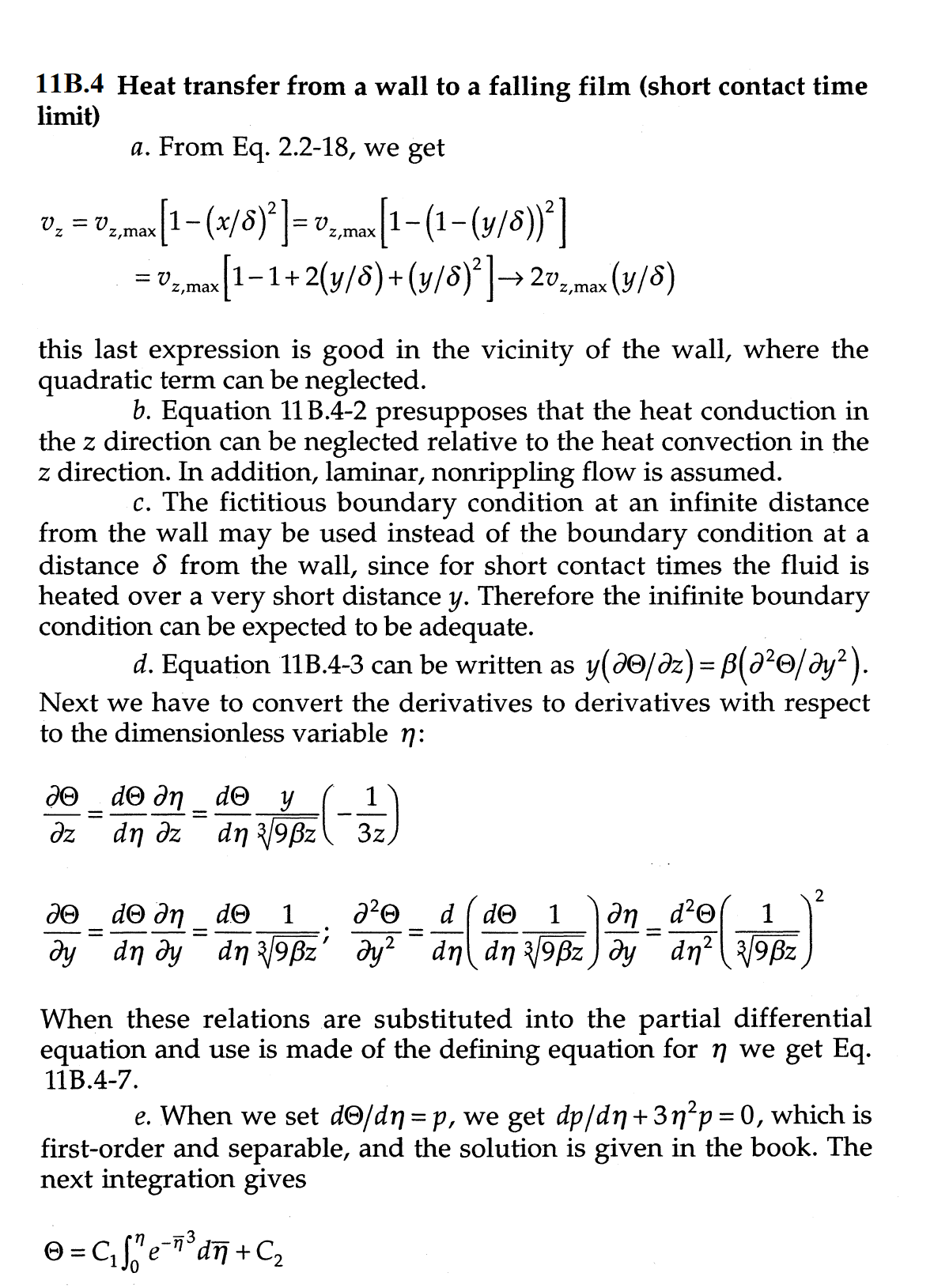


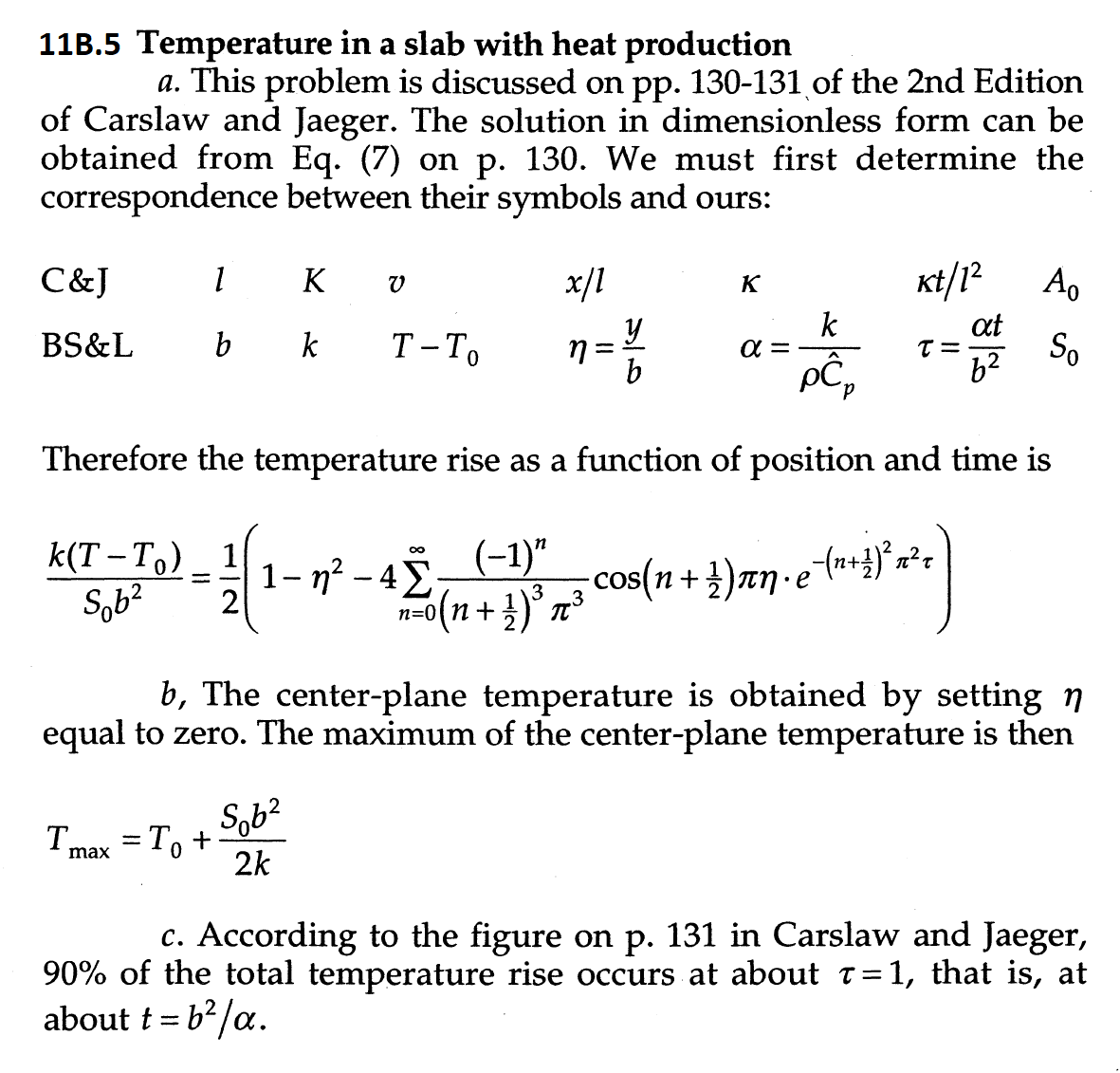
The conversion factor was taken from Table F.3-5.

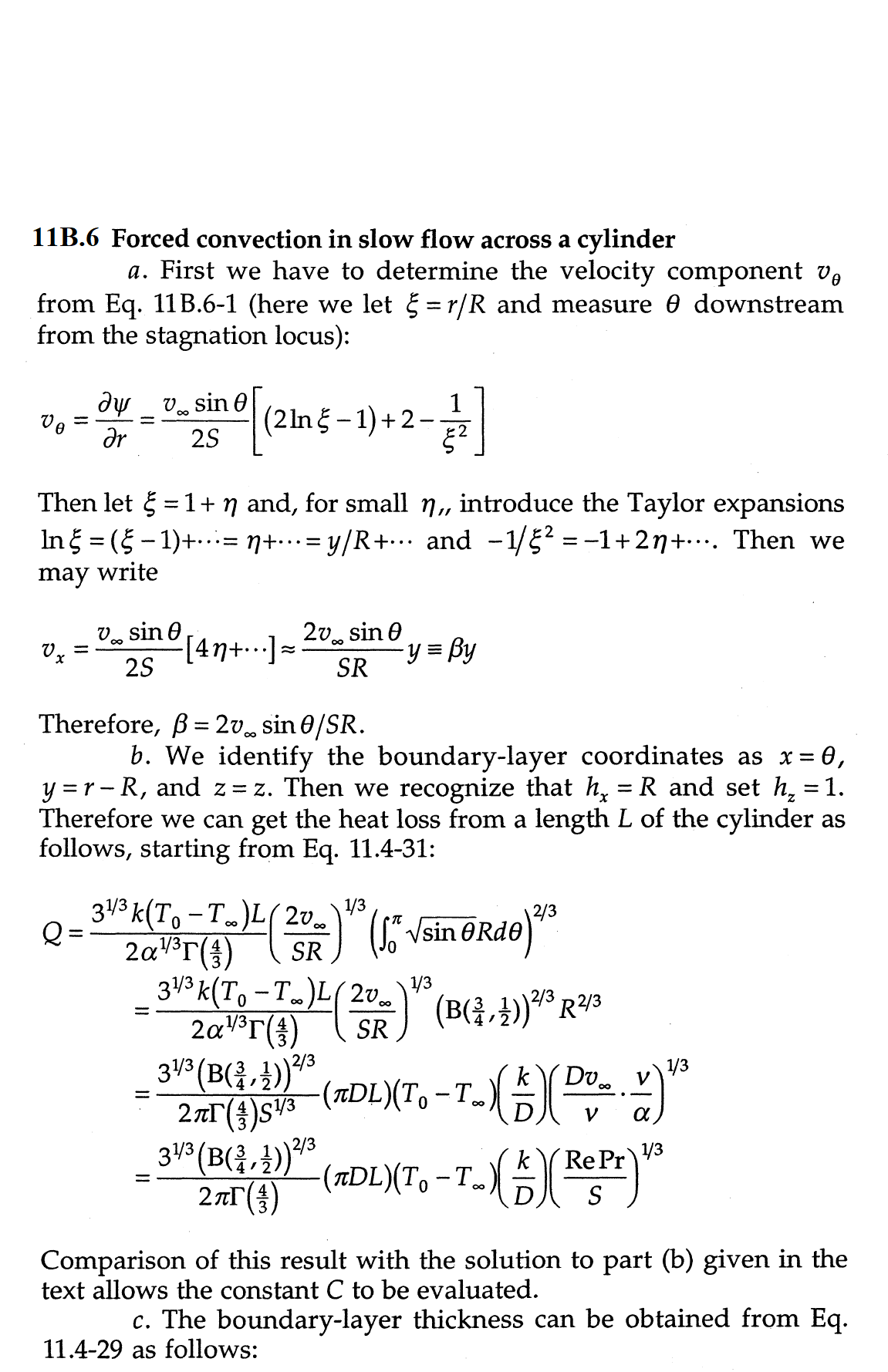


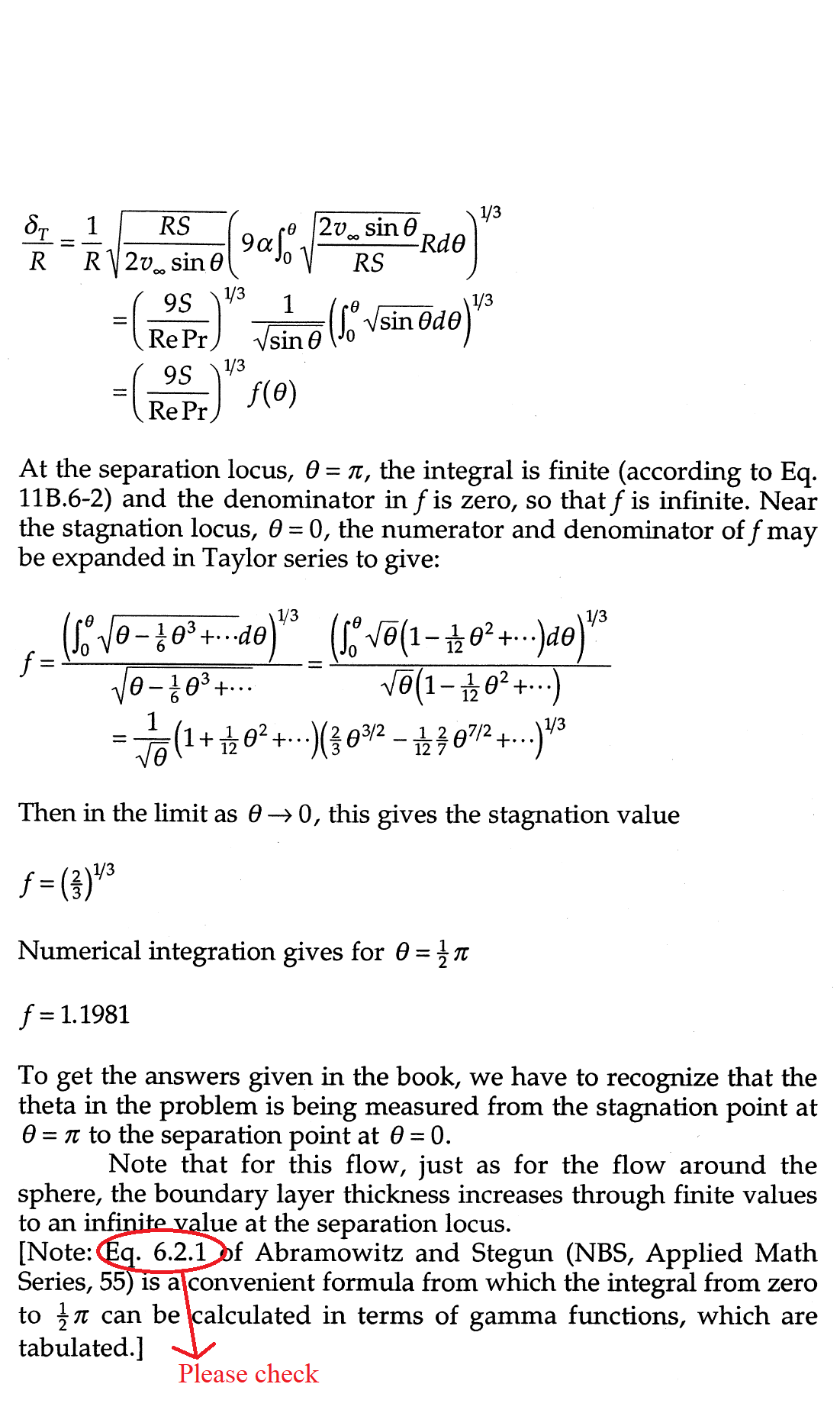














**11B.7 Timetable for roasting turkey.**

*a*. One dimensional diffusion equation for the temperature at any point *x* and instant time *t* inside the turkey.

(Eq. 1)

Where is the thermal diffusivity of the turkey.

Boundary and initial conditions:

(Eq. 2)

(Eq. 3)

(Eq. 4)

Write in terms of dimensionless terms:

; ; , (Eq. 5)

In the dimensionless form Eq. 1 becomes:

(Eq. 6)

And the boundary conditions in dimensionless form:

(Eq. 7)

(Eq. 8)

(Eq. 9)

The to Eq. 6 with boundary conditions Eq 7-9 will be of the form:

This is similar to the analysis in the example 11.1-4 with an arbitrary shape of the solid.

***b*. The is for the form:**

Given that the geometric ratios are of same and the temperature distribution is also same:

Then we have that dimensionless time is same for both turkeys:

(Eq.10)

If the turkeys are identical then the thermal diffusivity is same:

(Eq.11)

Therefore, we have:

(Eq.12)

The mass of the turkey is

(Eq.13)

If we assume the turkey is of same density then:

(Eq.14)

We assume that the volume of the turkey is proportional to cube of characteristic length then:

(Eq.14)

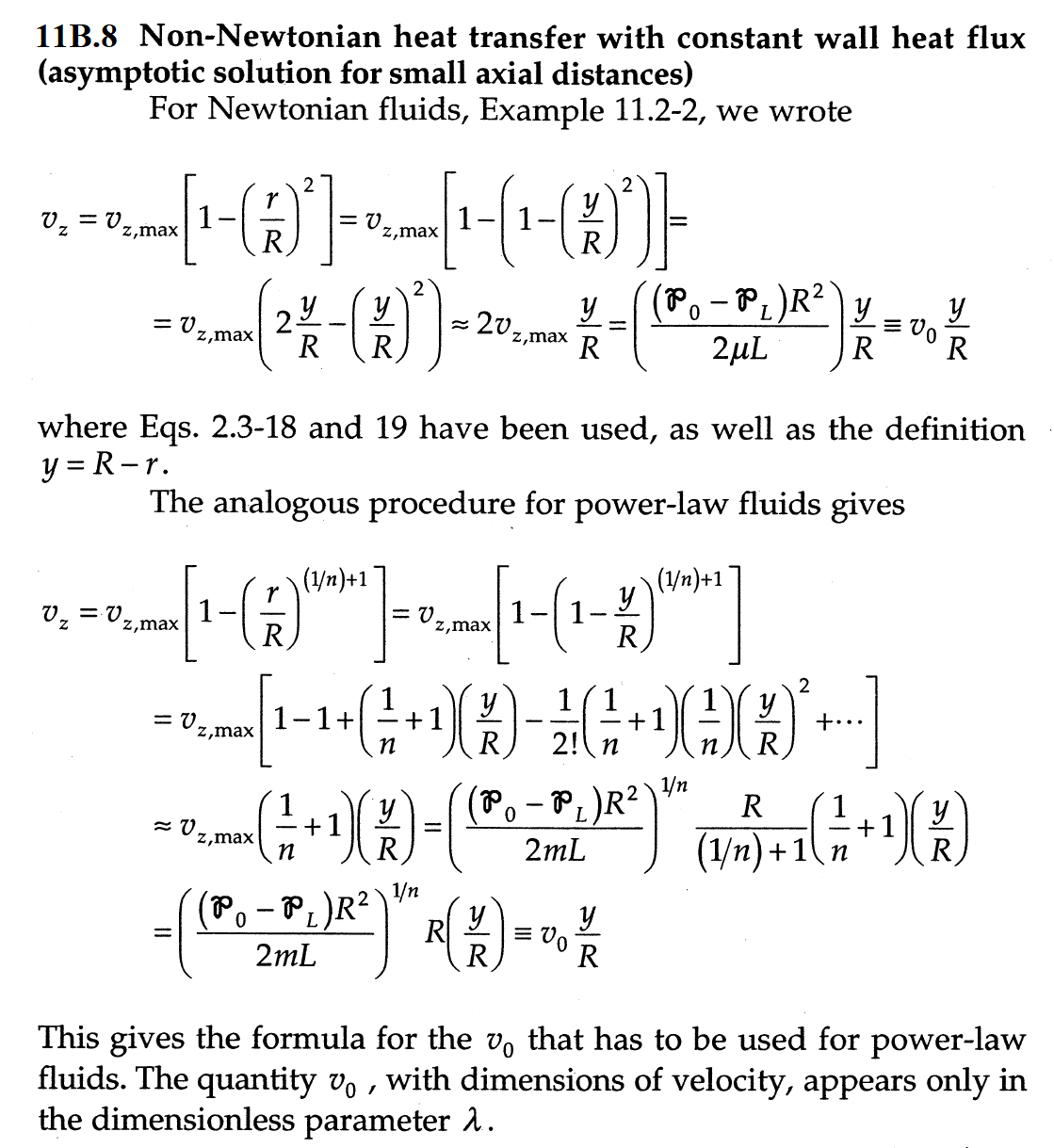
Therefore from Eq. 12 we get:

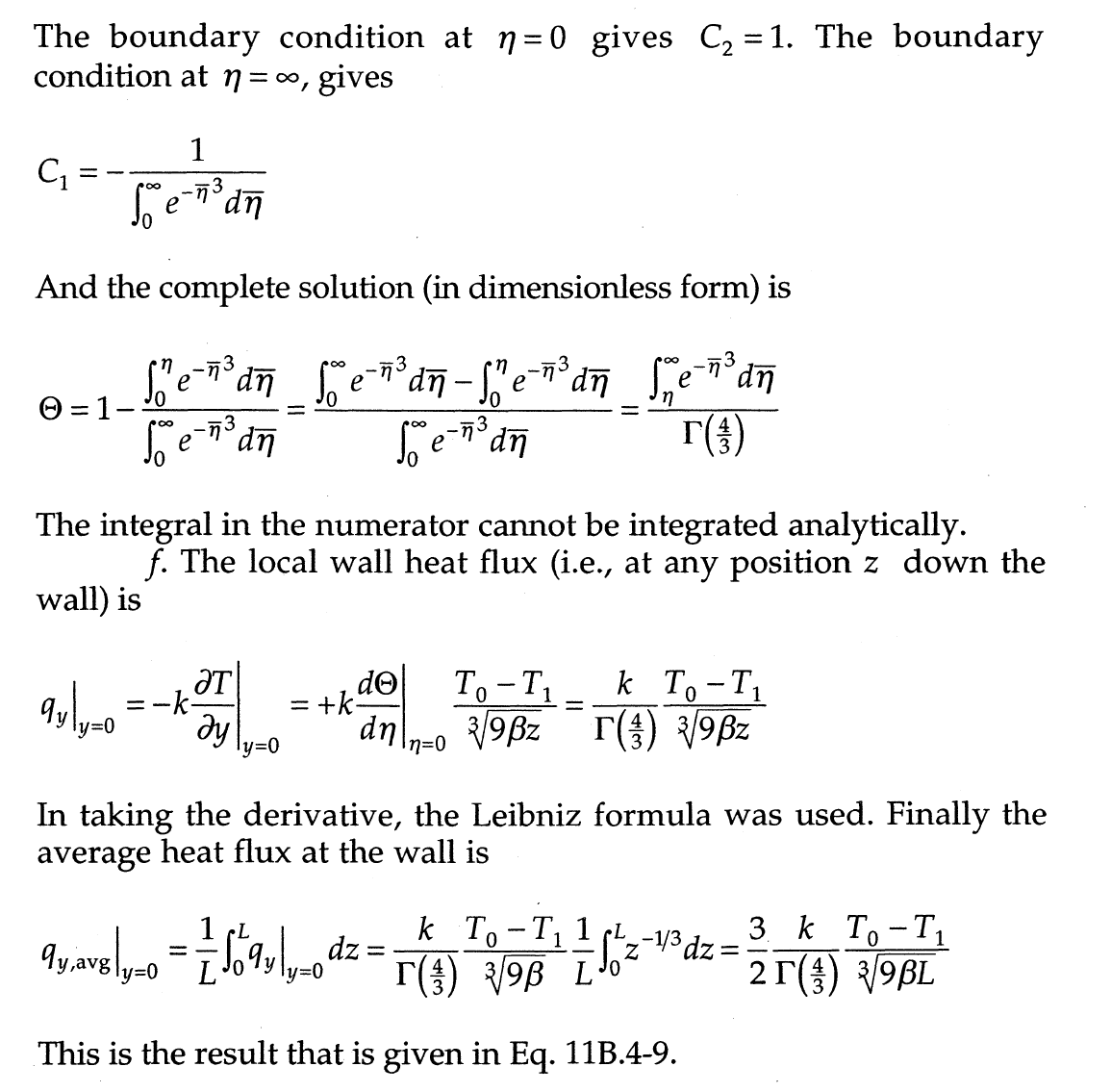
(Eq.15)

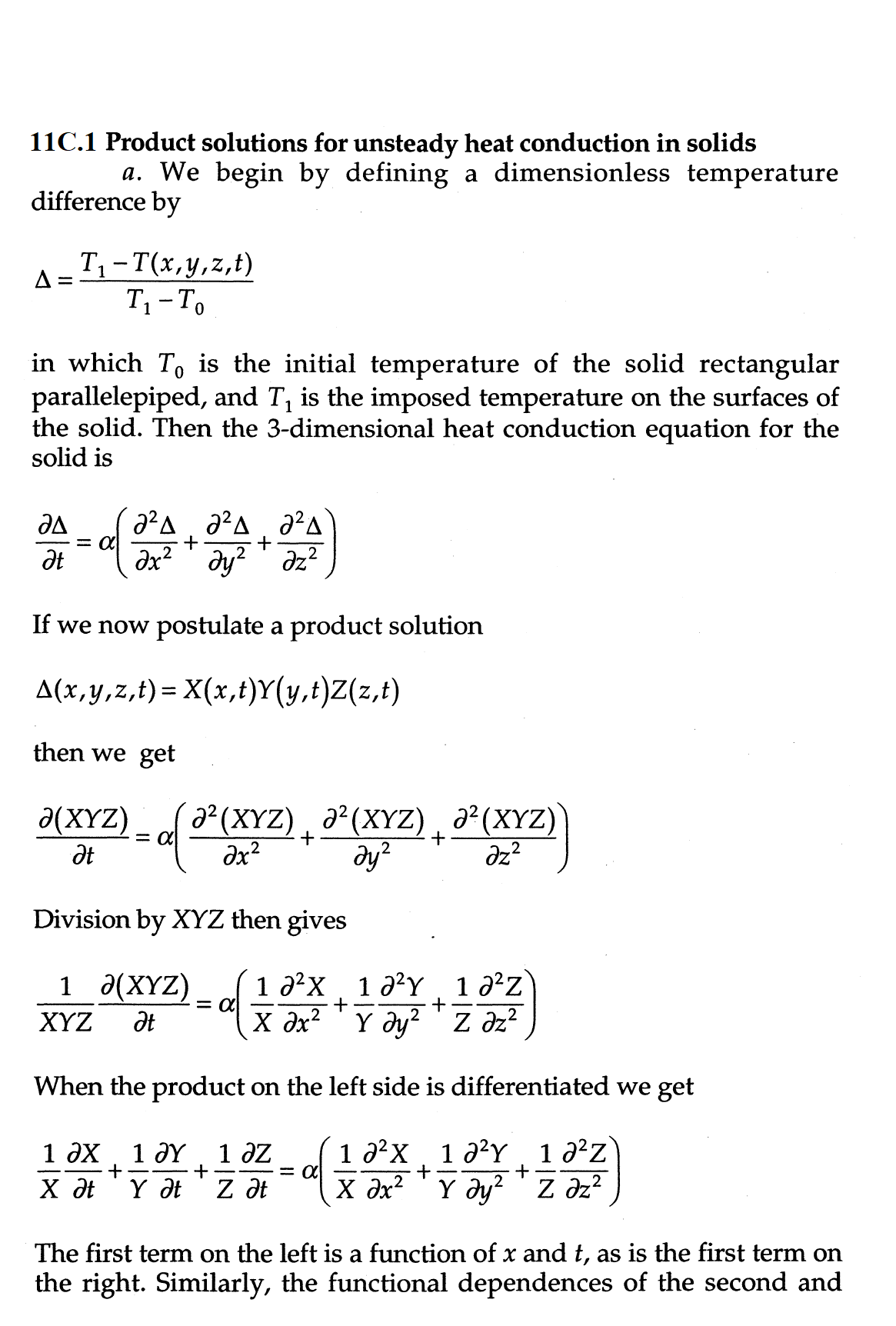
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| **Table 1** | | |
| **Mass of Turkey (kg)** | **Time required per unit mass (min/kg)** | **Time required (min)** |
| 2.7-4.5 | 44-55 | 118.8-247.5 |
| 4.5-7.26 | 40-44 | 180-319.44 |
| 8.16-11.34 | 33-40 | 269.28-453.6 |

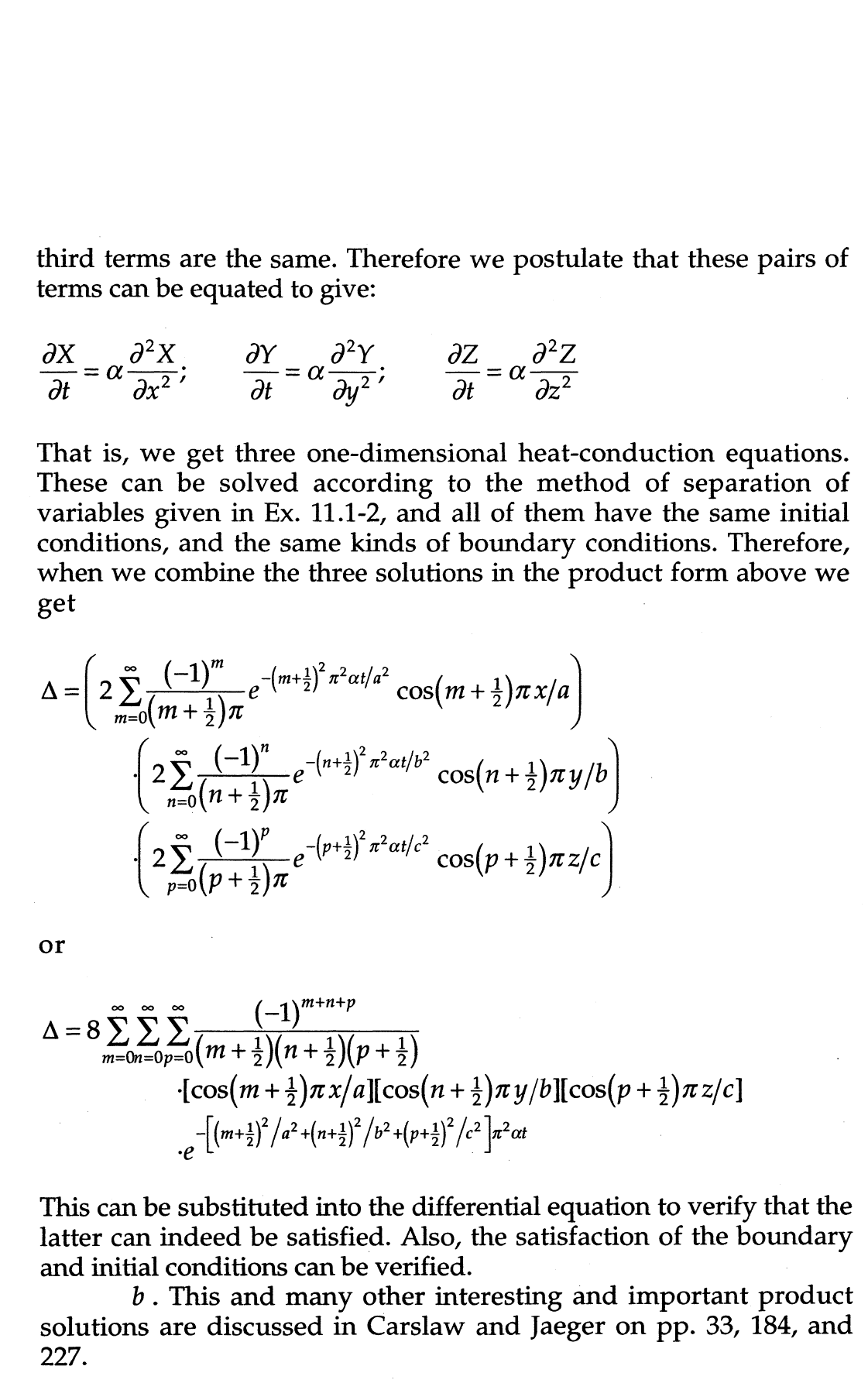
Predicted values assuming 2.7 kg require 118.8 minutes to cook are shown in table 2. The predicted values from dimensionless analysis shows agreement with the empirical cooking data.

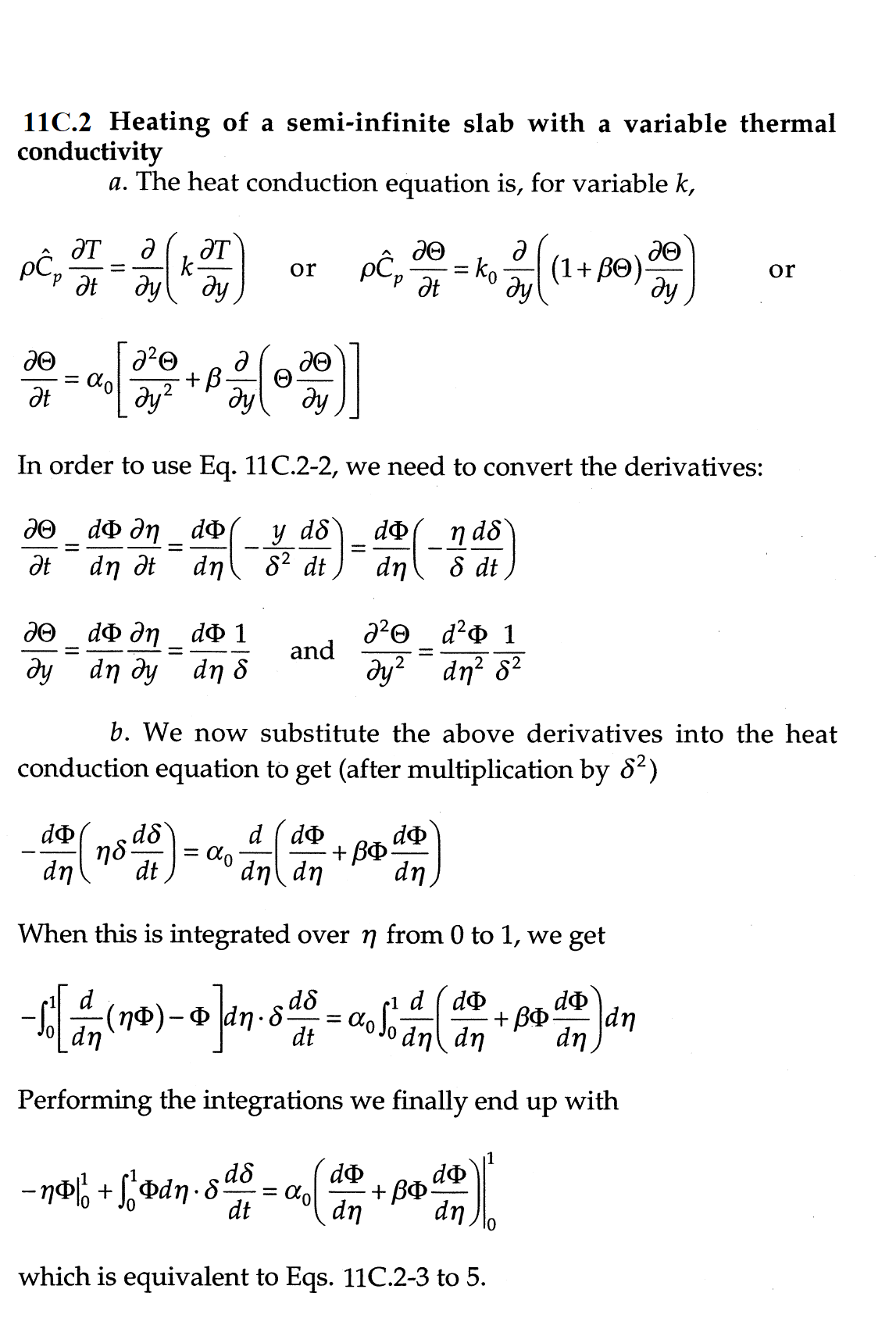
|  |  |
| --- | --- |
| **Table 2** | |
| **Mass of Turkey (kg)** | **Time required (kg)** |
| 2.7 | 118.8 |
| 4 | 154.4 |
| 6 | 202.3 |
| 8 | 245 |
| 10 | 284.38 |
| 11 | 303 |

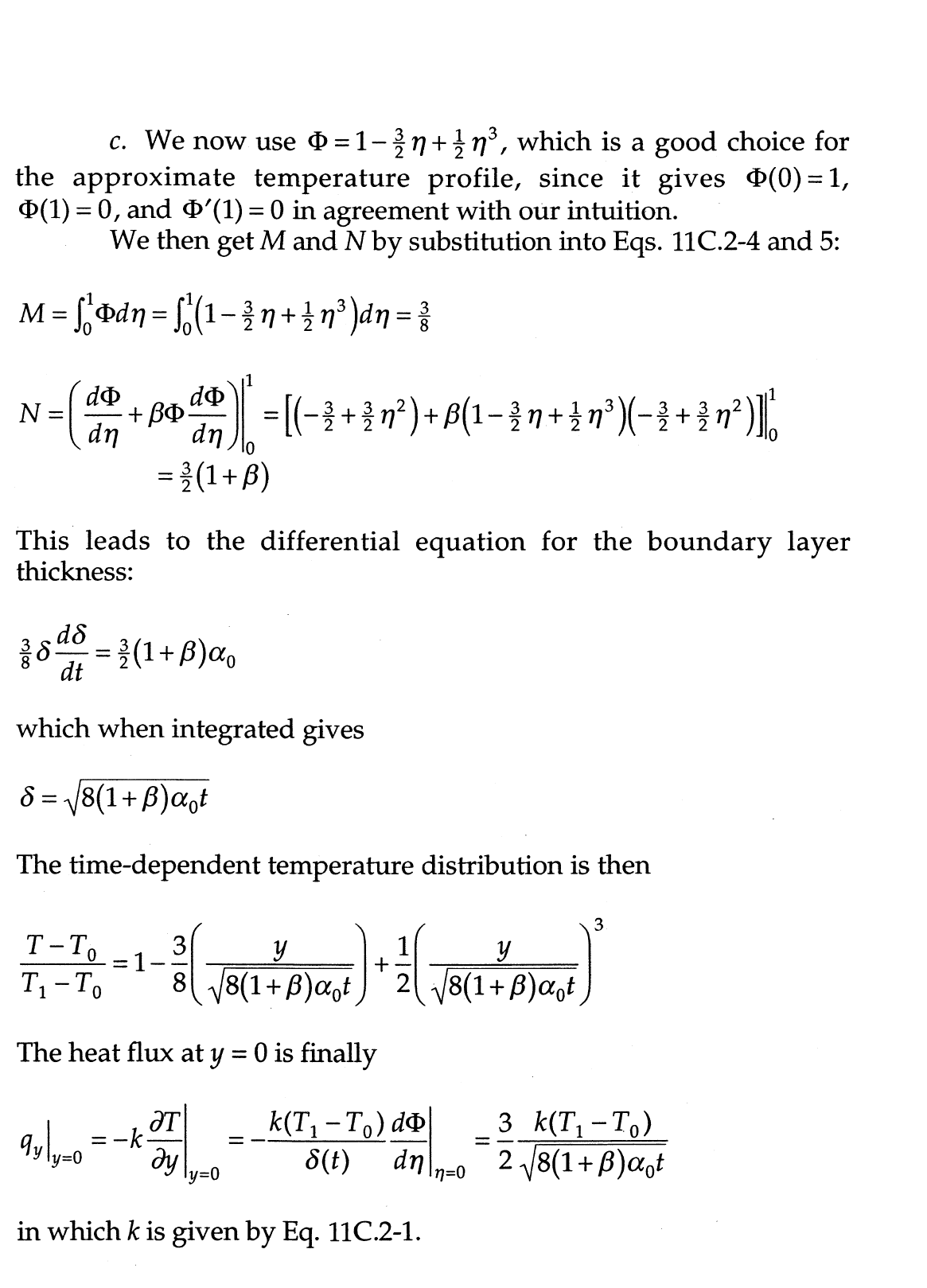
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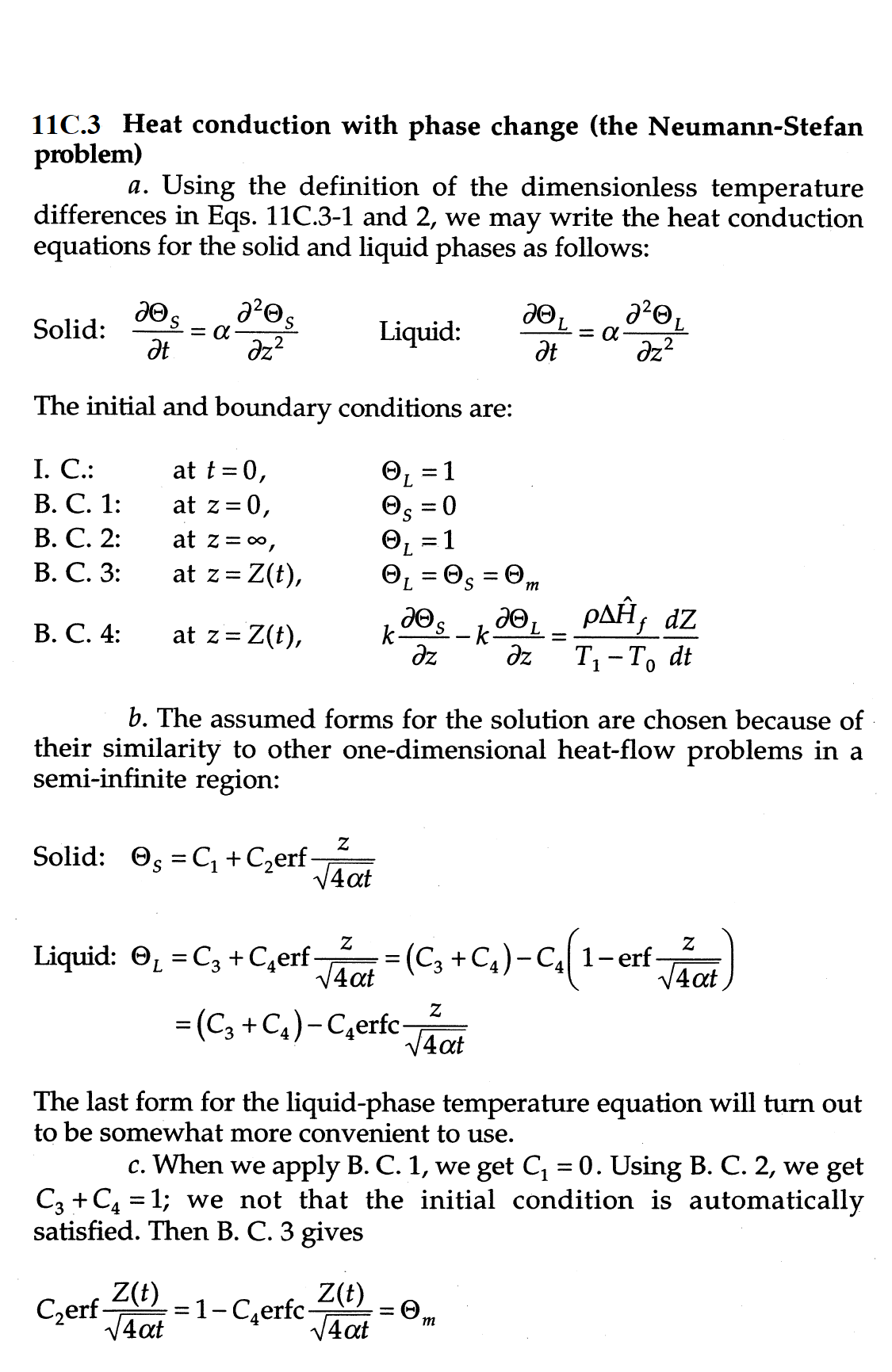
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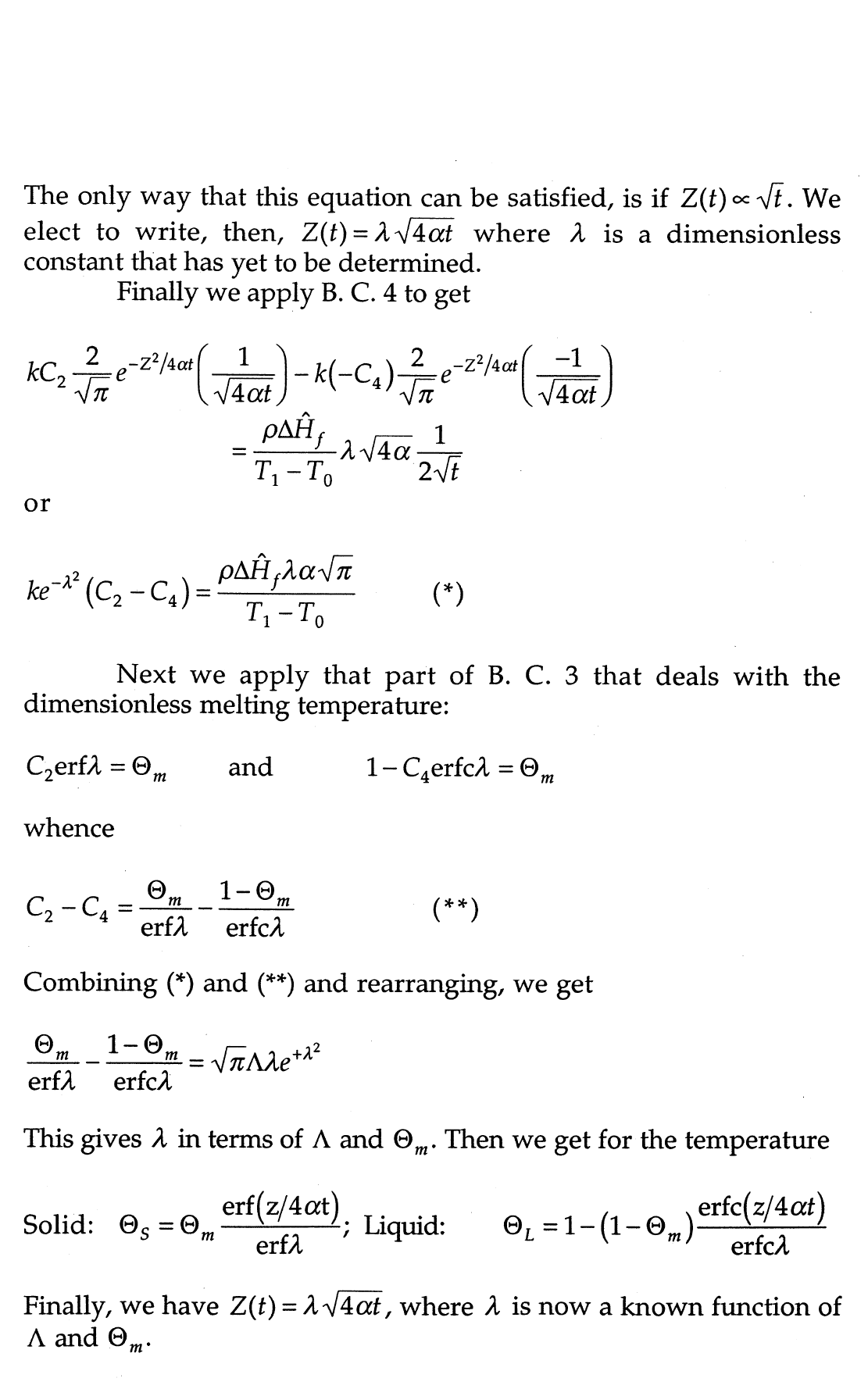
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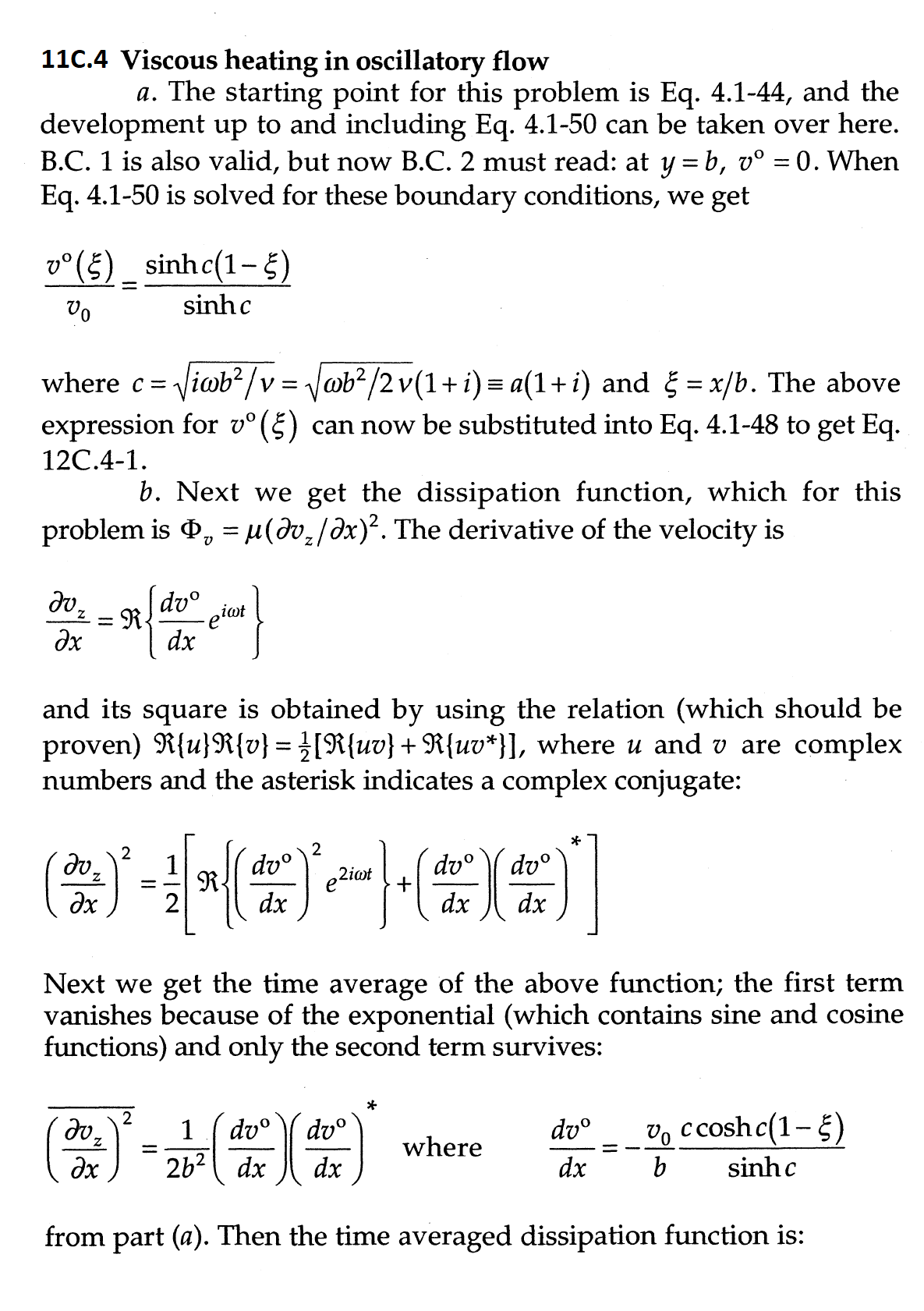
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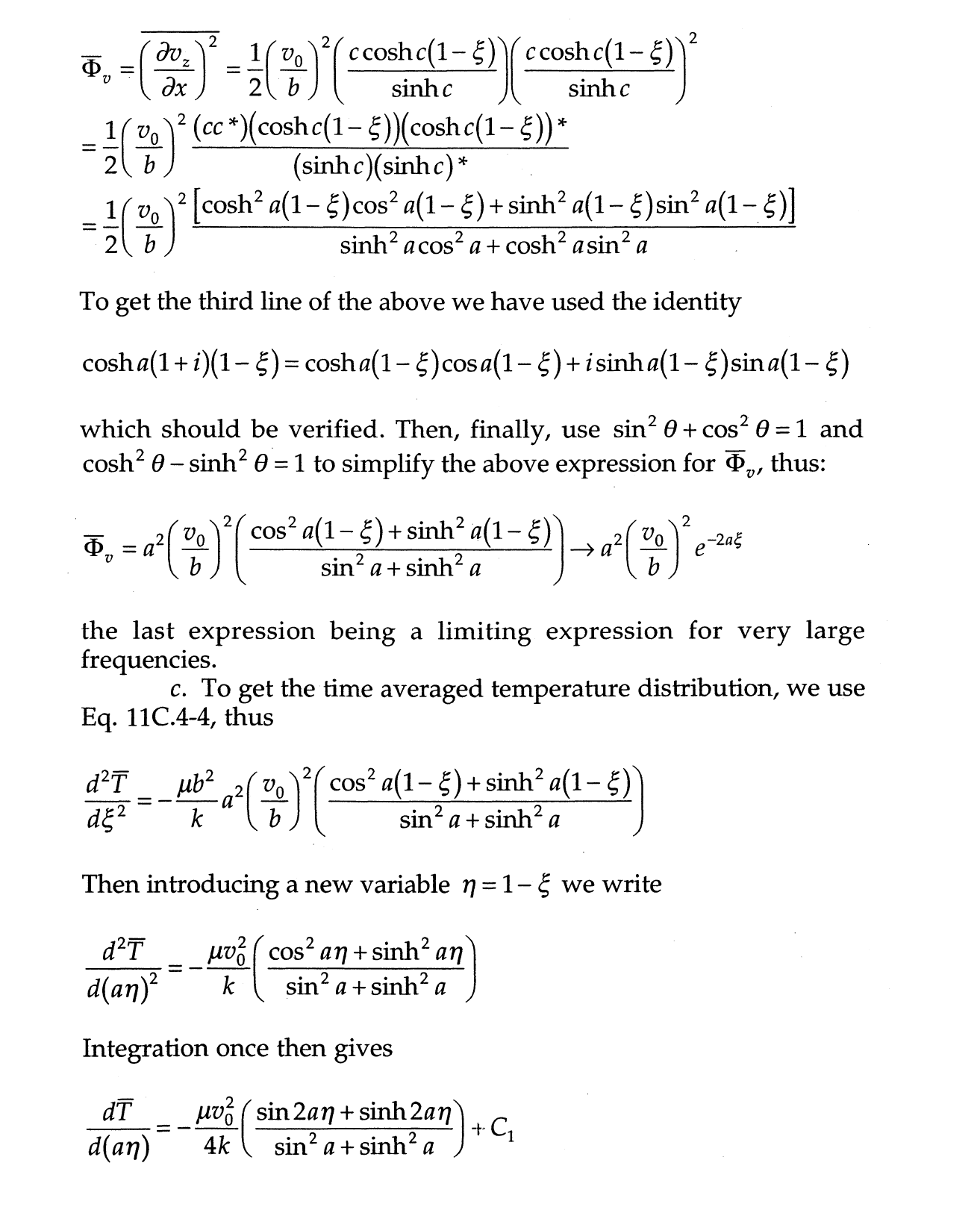
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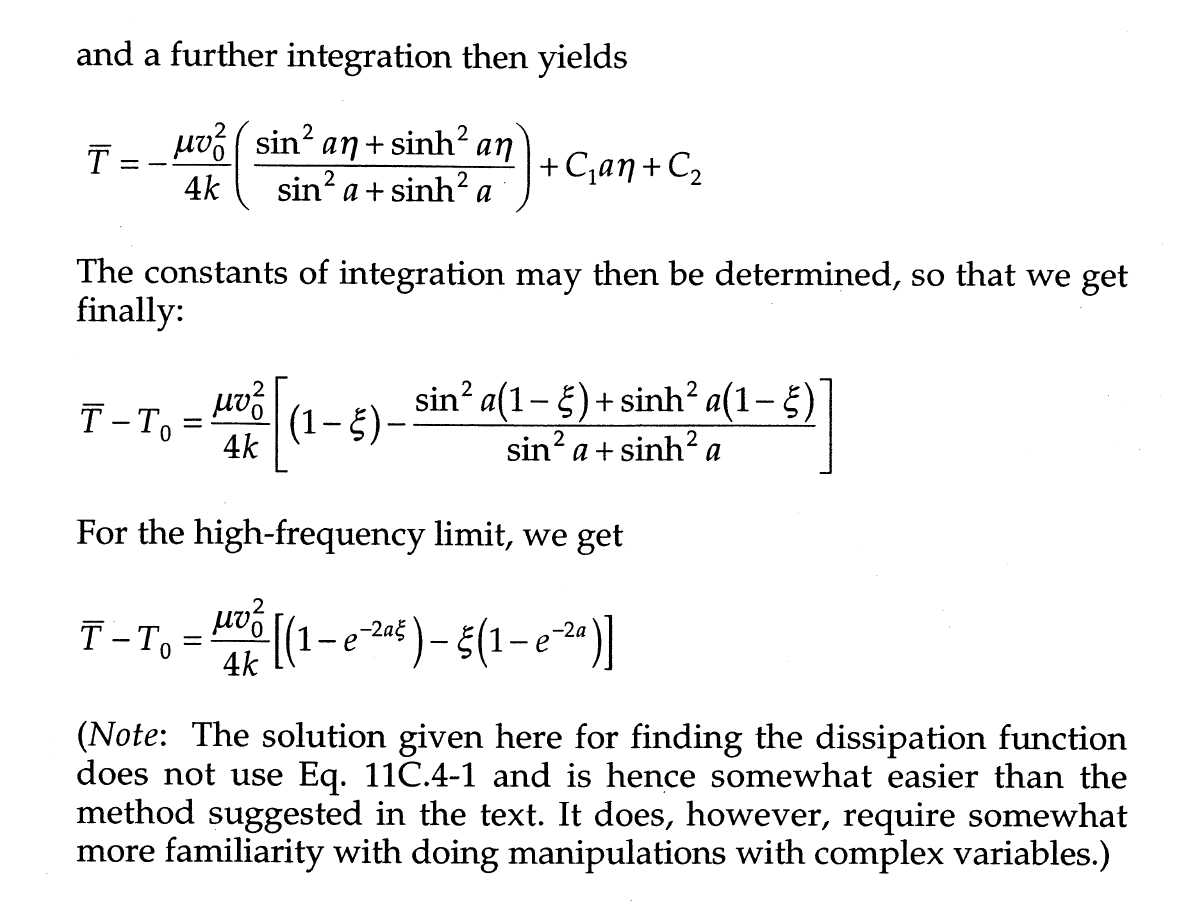
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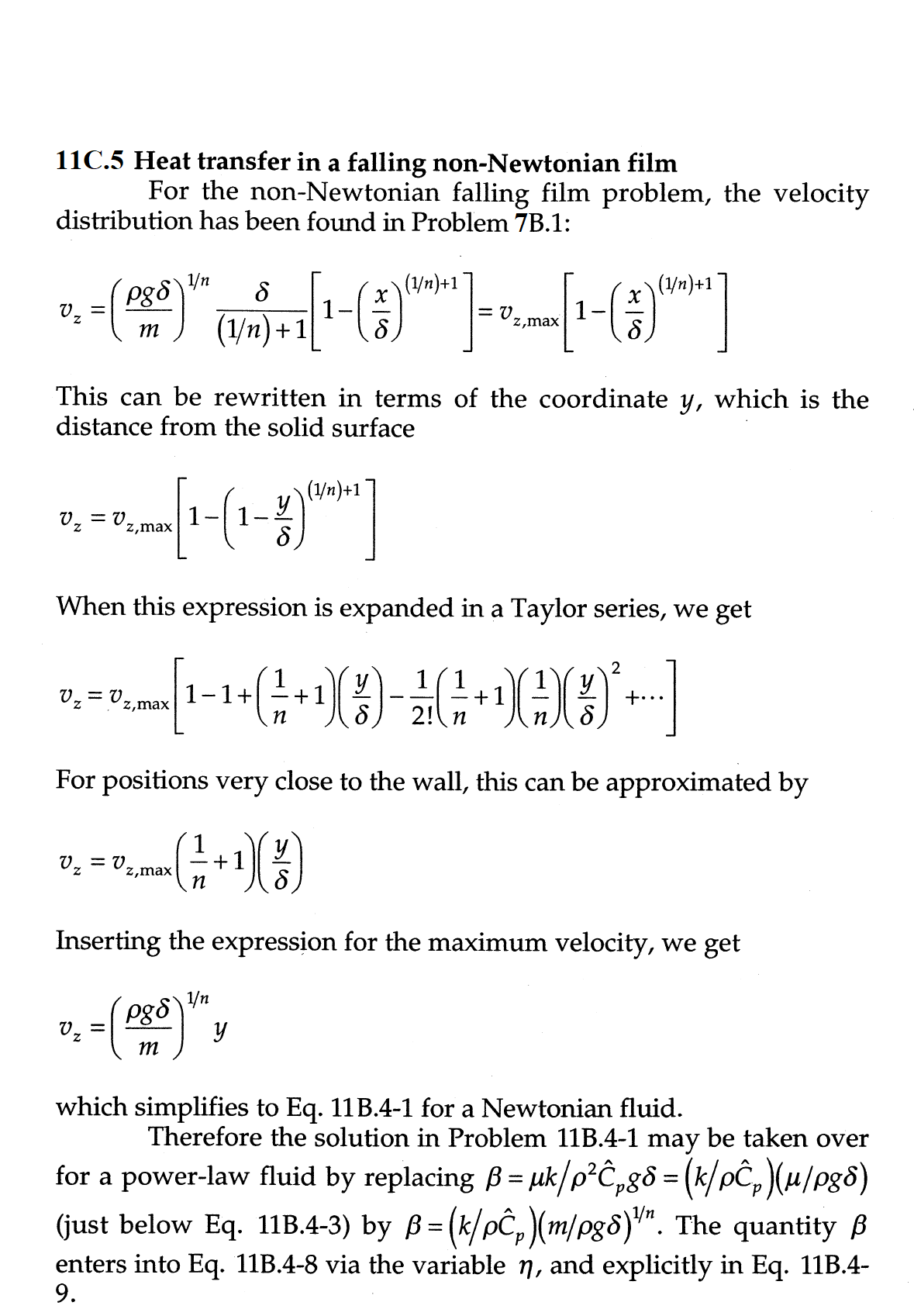
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