
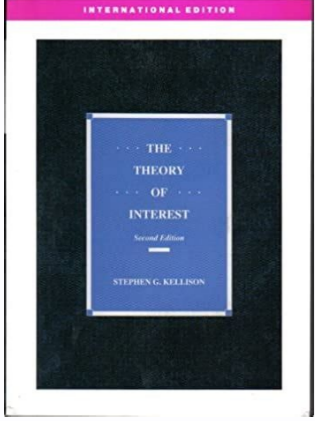


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Everything You Need to Know About Modular Arithmetic...

Math 135, February 7, 2006

Definition Let $m > 0$ be a positive integer called the *modulus*. We say that two integers a and b are congruent modulo m if $b - a$ is divisible by m . In other words,

$$a \equiv b \pmod{m} \iff a - b = m \cdot k \text{ for some integer } k. \tag{1}$$

Note:

1. The notation $?? \equiv ?? \pmod{m}$ works somewhat in the same way as the familiar $?? = ??$.
2. a can be congruent to many numbers modulo m as the following example illustrates.

Ex. 1 The equation

$$x \equiv 16 \pmod{10}$$

has solutions $x = \dots, -24, -14, -4, 6, 16, 26, 36, 46, \dots$. This follows from equation (1) since any of these numbers minus 16 is divisible by 10. So we can write

$$x \equiv \dots - 24 \equiv -14 \equiv -4 \equiv 6 \equiv 16 \equiv 26 \equiv 36 \equiv 46 \pmod{10}.$$

Since such equations have many solutions we introduce the notation $a \pmod{m}$.

Definition The symbol

$$a \pmod{m} \tag{2}$$

denotes the smallest positive number x such that

$$x \equiv a \pmod{m}.$$

In other words, $a \pmod{m}$ is the remainder when a is divided by m as many times as possible. Hence in example 1 we have

$$6 \equiv 16 \pmod{10} \text{ and } 6 \equiv -24 \pmod{10} \text{ etc....}$$

Relation between " $x \equiv b \pmod{m}$ " and " $x = b \pmod{m}$ "

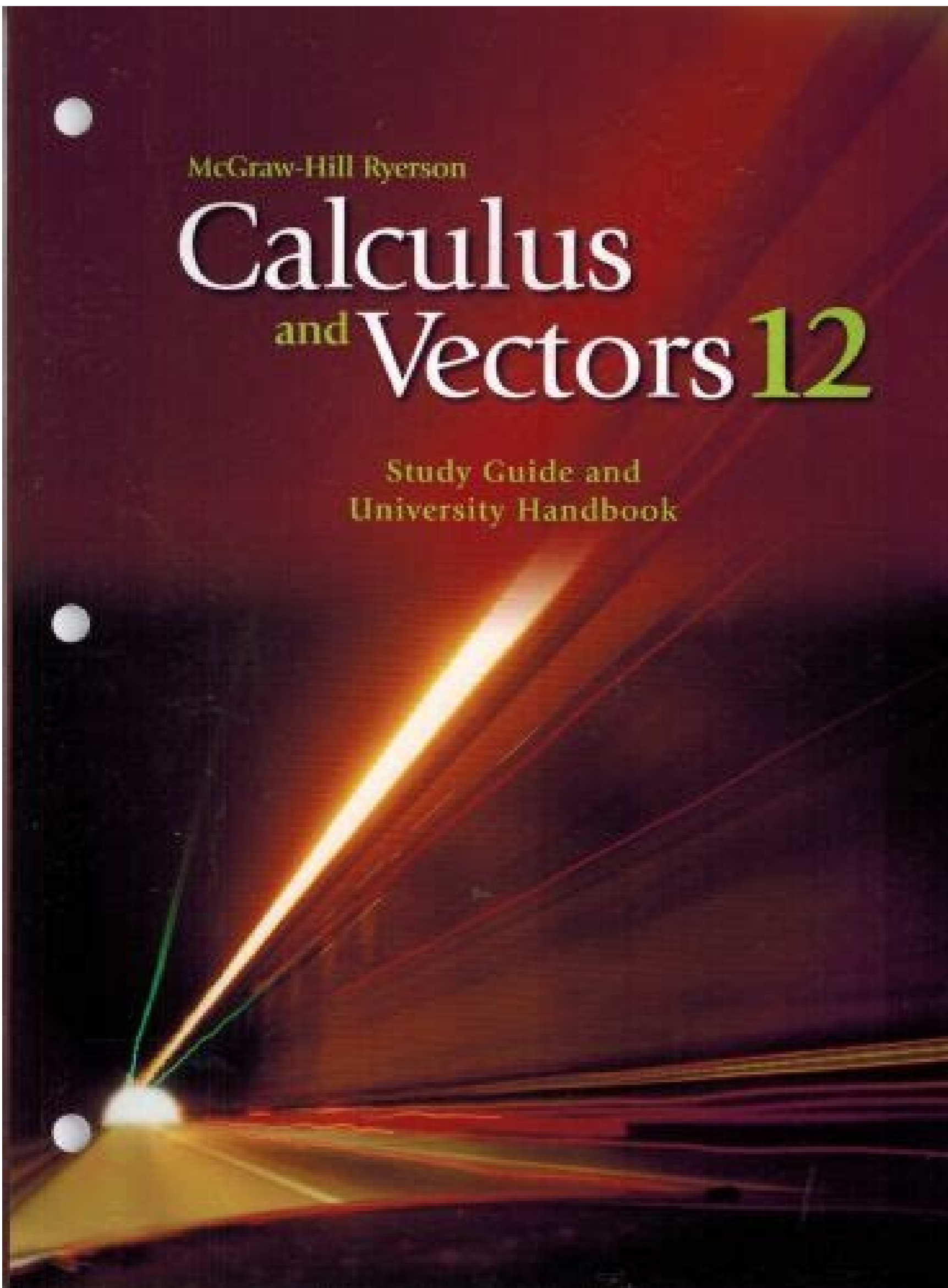
$x \equiv b \pmod{m}$ is an EQUIVALENCE relation with many solutions for x while $x = b \pmod{m}$ is an EQUALITY. So one can think of the relationship between the two as follows

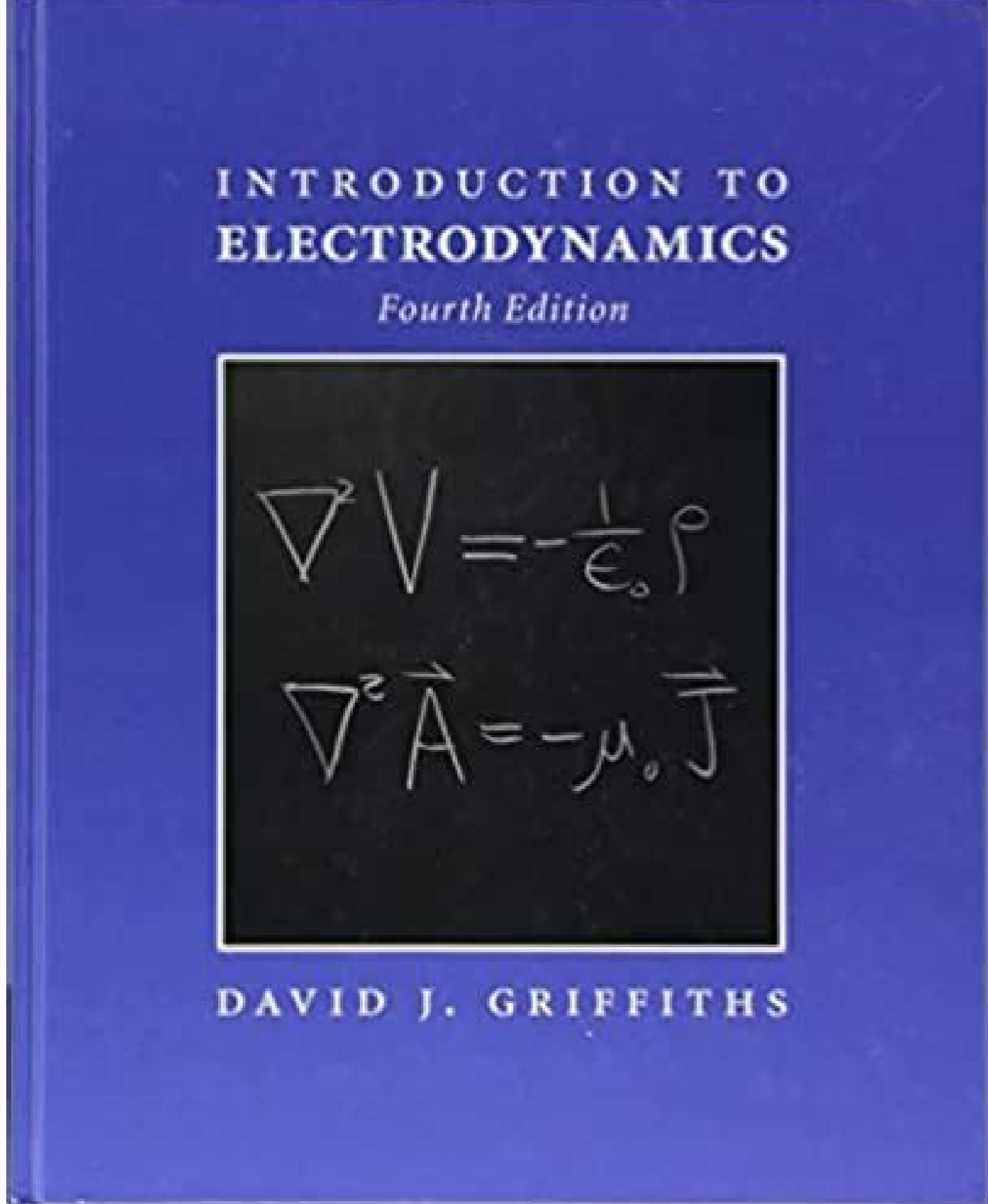
$$x = b \pmod{m} \text{ is the smallest positive solution to the equation } x \equiv b \pmod{m}.$$

Since

$$0 < b \pmod{m} < m$$

it is convention to take these numbers as the representatives for the class of numbers $x \equiv b \pmod{m}$.





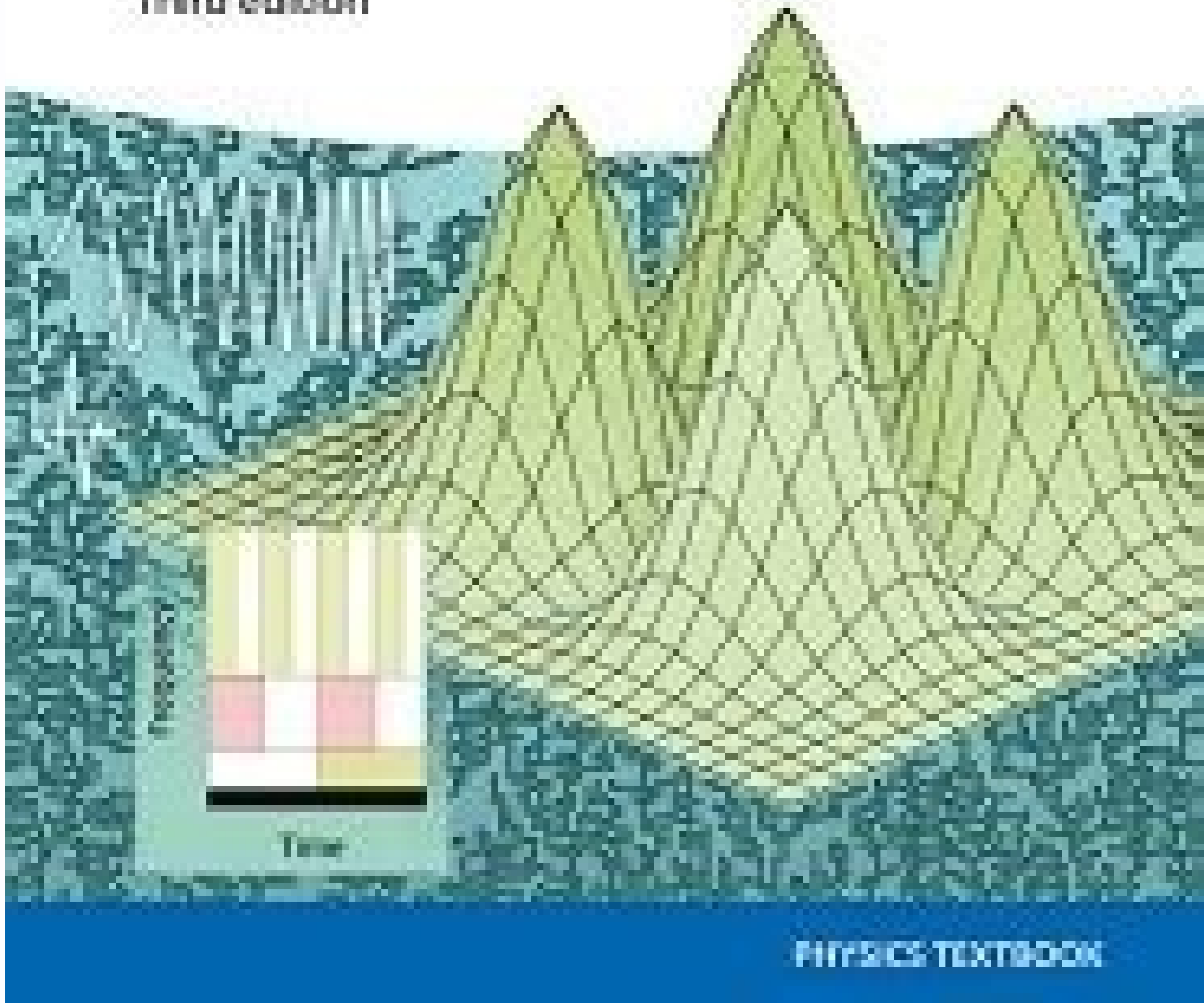
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