

# Abstract Algebra: An Introduction, 3rd

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## Chapter 1

## Arithmetic in $\mathbb{Z}$ Revisited

### 1.1 The Division Algorithm

- $q = 4, r = 1.$
  - $q = 0, r = 0.$
  - $q = -5, r = 3.$
- $q = -9, r = 3.$
  - $q = 15, r = 17.$
  - $q = 117, r = 11.$
- $q = 6, r = 19.$
  - $q = -9, r = 54.$
  - $q = 62720, r = 92.$
- $q = 15021, r = 132.$
  - $q = -14940, r = 335.$
  - $q = 39763, r = 3997.$
- Suppose  $a = bq + r$ , with  $0 \leq r < b$ . Multiplying this equation through by  $c$  gives  $ac = (bc)q + rc$ . Further, since  $0 \leq r < b$ , it follows that  $0 \leq rc < bc$ . Thus this equation expresses  $ac$  as a multiple of  $bc$  plus a remainder between 0 and  $bc - 1$ . Since by Theorem 1.1 this representation is unique, it must be that  $q$  is the quotient and  $rc$  the remainder on dividing  $ac$  by  $bc$ .
- When  $q$  is divided by  $c$ , the quotient is  $k$ , so that  $q = ck$ . Thus  $a = bq + r = b(ck) + r = (bc)k + r$ . Further, since  $0 \leq r < b$ , it follows (since  $c \geq 1$ ) that  $0 \leq r < bc$ . Thus  $a = (bc)k + r$  is the unique representation with  $0 \leq r < bc$ , so that the quotient is indeed  $k$ .
- Answered in the text.
- Any integer  $n$  can be divided by 4 with remainder  $r$  equal to 0, 1, 2 or 3. Then either  $n = 4k$ ,  $4k + 1$ ,  $4k + 2$  or  $4k + 3$ , where  $k$  is the quotient. If  $n = 4k$  or  $4k + 2$  then  $n$  is even. Therefore if  $n$  is odd then  $n = 4k + 1$  or  $4k + 3$ .
- We know that every integer  $a$  is of the form  $3q$ ,  $3q + 1$  or  $3q + 2$  for some  $q$ . In the last case  $a^2 = (3q + 2)^2 = 9q^2 + 12q + 4 = 3(3q^2 + 4q + 1) + 1$ . Other cases are similar.
- Suppose  $a = bq + r$  where  $0 \leq r < a$  and  $c = bq' + r'$  where  $0 \leq r' < a$ . If  $r = r'$  then  $a - c = b(q - q')$  and  $k = q - q'$  is an integer. Conversely, given  $a - c = ak$  we can substitute to find:  $(r - r') = a(k - q + q')$ . Suppose  $r \geq r'$  (the other case is similar). The given inequalities imply that  $0 \leq (r - r') < a$  and it follows that  $a(k - q + q') < 1$  and we conclude that  $k - q + q' = 0$ . Therefore  $r = r' = 0$ , so that  $r = r'$  as claimed.

# Hungerford Abstract Algebra Solutions

**Padhraic Smyth**



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**A Journey Through The Realm of Numbers** Menny Aka, Manfred Einsiedler, Thomas Ward, 2020-10-03 This book takes the reader on a journey from familiar high school mathematics to undergraduate algebra and number theory The journey starts with the basic idea that new number systems arise from solving different equations leading to abstract algebra Along this journey the reader will be exposed to important ideas of mathematics and will learn a little about how mathematics is really done Starting at an elementary level the book gradually eases the reader into the complexities of higher mathematics in particular the formal structure of mathematical writing definitions theorems and proofs is introduced in simple terms The book covers a range of topics from the very

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The Bulletin of Mathematics Books, 1992      *Group Theory* Parthiban Srinivasan, 2025-02-20

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