

# Math Studies Algebra: homework #7\*

## Due 22 October 2018, at start of class

Collaboration and use of external sources are permitted, but must be fully acknowledged and cited. For your own learning, you are advised to work individually. Collaboration may involve only discussion; all the writing must be done individually.

Homework must be submitted in L<sup>A</sup>T<sub>E</sub>X via e-mail under the same rules as the previous homeworks.

1. A proper subring  $M$  of  $R$  is *maximal* if there is no proper subring  $R'$  of  $R$  such that  $M$  is a proper subring of  $R'$ . Does every ring with at least two elements contain a maximal subring?
2. Suppose  $R_1, R_2, \dots$  is an infinite sequence of rings, and we have ring homomorphisms  $\phi_i: R_{i+1} \rightarrow R_i$  for each  $i$ . Let  $R$  be the set whose elements are sequences  $(x_1, x_2, \dots)$  with  $x_i \in R_i$  satisfying  $\phi_i(x_{i+1}) = x_i$ . Define addition and multiplication componentwise.
  - (a) Show that with these operations,  $R$  is a ring.
  - (b) Let  $N \geq 2$  be an integer. Show that the map  $\phi_i: \mathbb{Z}/N^{i+1}\mathbb{Z} \rightarrow \mathbb{Z}/N^i\mathbb{Z}$  given by  $\phi_i(x) \stackrel{\text{def}}{=} x + N^i\mathbb{Z}$  is a ring homomorphism.
  - (c) Let  $N = 7$ , and  $R_i = \mathbb{Z}/7^i\mathbb{Z}$ , and let  $\phi_i: \mathbb{Z}/7^{i+1}\mathbb{Z} \rightarrow \mathbb{Z}/7^i\mathbb{Z}$  be as above. Define  $R$  as in part (a). Show that the equation  $x^2 = 2$  has a solution in  $R$ . (Here  $2 = (2, 2, 2, \dots)$ .)
3. The *center* of a ring  $R$  is  $\{z \in R : zr = rz \text{ for all } r \in R\}$ .
  - (a) Show that the center of  $R$  is a subring of  $R$ .
  - (b) Let  $R$  be a commutative ring with the identity, and let  $G$  be a group. Find the center of the group ring  $RG$ .
4. (Bonus problem) Show that if a ring  $R$  is infinite, then the number of zero divisors in  $R$  is either zero or infinite.

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\*This homework is from <http://www.borisbukh.org/MathStudiesAlgebra1819/hw7.pdf>.