

## Problem Set 9

Due Thursday, November 6

**Instructions:** You are encouraged to work together on these problems, but each student should hand in their own final draft, written in a way that indicates their individual understanding of the solutions. Never submit something for grading that you do not completely understand. You cannot use any resources besides me, your classmates, and our course notes.

I will post the .tex code for these problems for you to use if you wish to type your homework. If you prefer not to type, please *write neatly*. As a matter of good proof writing style, please use complete sentences and correct grammar. You may use any result stated or proven in class or in a homework problem, provided you reference it appropriately by either stating the result or stating its name (e.g. the definition of ring or Lagrange's Theorem). Please do not refer to theorems by their number in the course notes, as that can change.

**Problem 1.** Prove that there is no simple group of order 48.

**Problem 2.** Let  $C_n$  denote the cyclic group of order  $n \geq 2$ , and consider the group

$$(\mathbb{Z}/n)^\times = \{[j]_n \mid \gcd(j, n) = 1\}$$

with the binary operation given by the usual multiplication. Prove that

$$\mathrm{Aut}(C_n) \cong (\mathbb{Z}/n)^\times.$$

**Problem 3.** Prove that<sup>1</sup> the quaternion group  $Q_8$  is not isomorphic to a semidirect product of nontrivial groups  $H, K$ .

**Problem 4.**

- (a) Show that there exists a nonabelian group of order 63.
- (b) Give a presentation for the group you found, with justification.

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<sup>1</sup>Hint: You can use without proof that every subgroup of  $Q_8$  is normal.