

Solutions to Principles of Mathematical Analysis (Walter Rudin)

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This work was done as an undergraduate student; if you really don't understand something in one of these proofs, it is very possible that it doesn't make sense because it's wrong. Any questions or corrections can be directed to jason.rosendale@gmail.com.

Exercise 1.1a

Let r be a nonzero rational number. We're asked to show that $x \notin \mathbb{Q}$ implies that $(r+x) \notin \mathbb{Q}$. Proof of the contrapositive:

- $\Rightarrow r+x$ is rational assumed
- $\rightarrow (\exists p \in \mathbb{Q})(r+x = p)$ definition of rational
- $\rightarrow (\exists p, q \in \mathbb{Q})(q+x = p)$ we're told that r is rational
- $\rightarrow (\exists p, q \in \mathbb{Q})(x = -q + p)$ existence of additive inverses in \mathbb{Q}

Because p and q are members of the closed additive group of \mathbb{Q} , we know that their sum is a member of \mathbb{Q} .

- $\rightarrow (\exists u \in \mathbb{Q})(x = u)$
- $\rightarrow x$ is rational definition of rational

By assuming that $r+x$ is rational, we prove that x must be rational. By contrapositive, then, if x is irrational then $r+x$ is irrational, which is what we were asked to prove.

Exercise 1.1b

Let r be a nonzero rational number. We're asked to show that $x \notin \mathbb{Q}$ implies that $rx \notin \mathbb{Q}$. Proof of the contrapositive:

- $\Rightarrow rx$ is rational assumed
- $\rightarrow (\exists p \in \mathbb{Q})(rx = p)$ definition of rational
- $\rightarrow (\exists p \in \mathbb{Q})(x = r^{-1}p)$ existence of multiplicative inverses in \mathbb{Q}

(Note that we can assume that r^{-1} exists only because we are told that r is nonzero.) Because r^{-1} and p are members of the closed multiplicative group of \mathbb{Q} , we know that their product is also a member of \mathbb{Q} .

- $\rightarrow (\exists u \in \mathbb{Q})(x = u)$
- $\rightarrow x$ is rational definition of rational

By assuming that rx is rational, we prove that x must be rational. By contrapositive, then, if x is irrational then rx is irrational, which is what we were asked to prove.

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