Numbers and Sets (2011–12)

Example Sheet 1 of 4

- 1. For which $n \in \mathbb{N}$, if any, are three numbers of the form n, n+2, n+4 all prime?
- **2.** Between 0 and 10 there are four primes. The same is true between 10 and 20. Are there two other consecutive multiples of ten between which there are four primes?
- **3.** If n^2 is a multiple of 3, must n be a multiple of 3?
- 4. Write down the negations of the following assertions (where $m, n, a, b \in \mathbb{N}$):
 - (i) if Coke is not worse than Pepsi then Osborne hasn't a clue what he's about.
 - (ii) $\forall m \exists n \forall a \forall b \ (n \ge m) \land [(a = 1) \lor (b = 1) \lor (ab \ne n)],$
- **5.** The sum of some (not necessarily distinct) natural numbers is 100. How large can their product be?
- 6. Prove that $A \setminus (B \cup C) = (A \setminus B) \cap (A \setminus C)$.
- 7. The symmetric difference $A \triangle B$ of two sets A and B is the set of elements that belong to exactly one of A and B. Express this in terms of \cup , \cap and \setminus . Prove that \triangle is associative.
- 8. Let A_1, A_2, A_3, \ldots be sets such that $A_1 \cap A_2 \cap \ldots \cap A_n \neq \emptyset$ holds for all n. Must it be that $\bigcap_{n=1}^{\infty} A_n \neq \emptyset$?
- **9.** Prove that $f \circ g$ is injective if f and g are injective. Does $f \circ g$ injective imply f injective? Does it imply g injective? What if we replace 'injective' by 'surjective' passim?
- 10. Let $A = \{1, 2, 3\}$ and $B = \{1, 2, 3, 4, 5\}$? How many functions $A \to B$ are there? How many are injections? Count the number of surjections $B \to A$.
- 11. Let $f : X \to Y$ and let $C, D \subset Y$. Prove that $f^{-1}(C \cap D) = f^{-1}(C) \cap f^{-1}(D)$. Let $A, B \subset X$. Must it be true that $f(A \cap B) = f(A) \cap f(B)$?
- 12. Define a relation R on N by setting aRb if $a \mid b$ or $b \mid a$. Is R an equivalence relation?
- **13.** The relation S contains the relation R if aSb whenever aRb. Let R be the relation on \mathbb{Z} 'aRb if b = a + 3'. How many equivalence relations on \mathbb{Z} contain R?
- 14. Find a bijection $f : \mathbb{Q} \to \mathbb{Q} \setminus \{0\}$. Can f be strictly increasing (that is, f(x) < f(y) whenever x < y)?