Math 55 Worksheet

Adapted from worksheets by Rob Bayer, Summer 2009.

Functions

1. Find the value of $\sum_{i=1}^{3}\sum_{j=1}^{3}(i-j)$ 0
2. Determine whether each of the following are injections, surjections, bijections, or none of the three.
   (a) $f:\mathbb{R}\to\mathbb{R}, f(x)=3x-2$ Bijection
   (b) $f:\mathbb{R}\to\mathbb{Z}, f(x)=\lfloor x\rfloor$ Surjective
   (c) $f:\mathbb{N}\to\mathbb{N}, f(n)=n+1$ Injective
   (d) $f:\mathbb{R}\to\mathbb{R}, f(x)=x(x-3)(x+2)$ Surjective
3. Write down the formal definitions of a *function*, *injectivity* and *surjectivity*. These will help with problem 4. A function is a rule which assigns to each x in the domain, a unique y in the range. We write this as $f(x)=y$.

   A function $f:X\to Y$ is injective if for $f(x_1)=f(x_2) \implies x_1=x_2$. (Note that the other direction is true as well, but I think it's less confusing to just worry about the one direction.

   A function $f:X\to Y$ is surjective if for all $y\in Y$ there exists an $x\in X$ such that $f(x)=y$.
4. Decide whether each of the following are true or false. For those that are true, prove it. For those that are false, provide a counterexample.
   (a) If f and g are injective, then so is $f\circ g$. True: Proof:

   To show that $f\circ g$ is injective, suppose that $f\circ g(x_1)=f\circ g(x_2)$. This means

   $f(g(x_1)) = f(g(x_2))$ But since f is injective, the things inside the parentheses must be equal. i.e. $g(x_1)=g(x_2)$. And since g is injective, we must have $x_1=x_2$. This implies that $f\circ g$ is injective.
   (b) If f and g are surjective, then so is $f\circ g$. True: Here it helps to suppose that $f:Y\to Z$ and $g:X\to Y$. (I should have included this in the problem. Proof:

   $f\circ g$ is a function from X to Z. To show it is surjective we need to show that if $z\in Z$ then there is some element $x\in X$ such that $f\circ g(x)=z$. To see this, notice that since f is surjective, there is a $y\in Y$ such that $f(y)=z$. And since g is surjective, there is an element $x\in X$ such that $g(x)=y$. Then finally, notice that $f\circ g(x)=f(g(x))=f(y)=z$. So we have found the required x.
   (c) If $g\circ f$ is injective, then so is f.True: Try this proof on your own :)
   (d) If $g\circ f$ is injective, then so is g. False: Can you draw a picture of why?
   (e) If f is not surjective, then $g\circ f$ is not surjective. False: The codomain of g might just be a single point, so that $g\circ f$ is surjective trivially, no matter what f is. Draw a picture of this!
5. Explain why non-injective functions have no inverse function
6. The Hotel Infinity is rather unique, in that it has infinitely many rooms, one for each natural number. However, due to a recent surge in demand, all the rooms are currently full and people are still coming at a ludicrous rate. Fortunately, the owner of the place has an intercom that lets him talk to all the current occupants, and all of them are perfectly happy to switch rooms if asked.

   (a) Given this situation, how can the owner find space for one more person?

   (b) If a bus with infinitely many passengers (one for each natural number) shows up, how can the owner accoommodate them?

   (c) If infinitely many buses each with infinitely many passengers shows up (again, infinite=one for each natural number), how can they be accommodated?

   Check out ''http://en.wikipedia.org/wiki/Hilbert's_paradox_of_the_Grand_Hotel''
7. Even when a function $f:A\to B$ is not invertible, we will often talk about the inverse image of a set $C\subseteq B$, which we denote by $f^{-1}(C)$ and which is defined as $\{x|f(x)\in C\}$. Determine each of the following:
   (a) $f^{-1}(\{September12\})$ where f :(People) $\to$ (days of year), $f(x)=x$'s birthday. The set of people who were born on September 12

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Reza Nazari,Ava Ross

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