MATH 117 - Assignment # 5 (Crowdmark) - Solutions **Due date: October 22**

1. Show that the function $F(x) = (x-a)^2(x-b)^2 + x$ with $a < b$ has the value $(a+b)/2$ at some point x.

Solution:

F(x) is a polynomial, so it is continuous for all $x \in \mathbb{R}$. We have

$F(a) = (a-a)^2(a-b)^2 + a = 0 + a = a$

$F(b) = (b-a)^2(b-b)^2 + b = 0 + b = b$

Since a < b, then $\frac{a+b}{2} \in (a,b) = (F(a), F(b))$.

Then we can get F(x) is continuous and $\frac{a+b}{2}$ lies on the interval [F(a), F(b)].

So by the IVT, there exists some point $c \in [a,b]$ such that $F(c) = \frac{a+b}{2}$.

2. Let $f(x)$ be a continuous function on $[a,b]$ whose range is $[a,b]$. Show that there is a point on the graph of $f(x)$ that intersects the line $y = x$. That is, show that there exists a number $c \in [a,b]$ such that $f(c) = c$.

Solution:

Let g(x) = f(x) - x. The function f(x) is continuous on [a,b] and so g(x) is continuous on [a,b].

We have:

$a \le f(x) \le b$

Then we have $g(a) = f(a) - a \ge 0$, $g(b) = f(b) - b \le 0$

So, by the IVT, there exists some point $c \in (a,b)$ such that $g(c) = 0$. Thus,

There exists $c \in (a,b)$ such that $f(c) - c = 0$ or $f(c) = c$.

3. a) Show that the function $h(x)$ defined by:

$$h(x) = \begin{cases} x^4 \sin\left(\frac{1}{x}\right), & x \neq 0 \\ 0, & x = 0 \end{cases}$$

is continuous on $(-\infty, \infty)$.

b) Consider the function $g(x) = \tan^{-1} x + x^3 + 1$. Show that there exists $c \in [-1,1]$ such that $g(c) = 0$.

Solution:

a) The function $x^{-1} \sin \frac{1}{x}$ is continuous for all $x \neq 0$; so we need to check continuity at x=0.:

h(0) = 0

$\lim_{x \to 0}(h(x)) = \lim_{x \to 0}(x^4 \sin(\frac{1}{x})) = 0$

Since $-1 \le \sin \frac{1}{x} \le 1$, we can get that $-x^4 \le x^4 \sin \frac{1}{x} \le x^4$.

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