

## Math 194, problem set #7

For discussion November 19

- (1) Let  $0 < x_i < \pi$ ,  $i = 1, \dots, n$  and set  $x = (x_1 + \dots + x_n)/n$ . Prove that

$$\prod_{i=1}^n \left( \frac{\sin x_i}{x_i} \right) \leq \left( \frac{\sin x}{x} \right)^n. \quad (\text{Putnam, 1978})$$

- (2) If  $a, b, c$  are positive real numbers, show that

$$\frac{a}{b+c} + \frac{b}{c+a} + \frac{c}{a+b} \geq \frac{3}{2}.$$

- (3) For every positive integer  $n$ , show that

$$\sqrt{1 + \sqrt{2 + \sqrt{3 + \dots + \sqrt{n}}}} < 2.$$

- (4) If  $f : \mathbf{Z}^+ \rightarrow \mathbf{Z}^+$  is an injective function, then for every  $n$

$$\sum_{k=1}^n \frac{f(k)}{k^2} \geq \sum_{k=1}^n \frac{1}{k}.$$

- (5) Prove that for every positive integer  $n$

$$\frac{n^n}{e^{n-1}} \leq n! \leq \frac{n^{n+1}}{e^{n-1}}.$$

- (6) Let  $f(x)$  be a function such that  $f(1) = 1$  and for  $x \geq 1$

$$f'(x) = \frac{1}{x^2 + f(x)^2}.$$

Prove that  $\lim_{x \rightarrow \infty} f(x)$  exists and is less than  $1 + \frac{\pi}{4}$ . (Putnam, 1947)

- (7) Show that if  $\epsilon(n) = 1/n$ , then for every  $n \geq 1$ ,

$$2\sqrt{n^2 + n} - 2n - \epsilon(n) < \sum_{i=1}^n \frac{1}{\sqrt{n^2 + i}} < 2\sqrt{n^2 + n} - 2n.$$

Can you improve the “error term”  $\epsilon(n)$ ?