Free Response Style Questions!!

1. Let f be a function that is twice differentiable for all real numbers. The table gives values of f for selected points in the closed interval $3 \le x \le 11$.

x	3	5	6	9	11
f(x)	2	1	-3	2	9

a. Estimate $f'(4)$. Show all work. **Remember, derivative = slope*

$$f'(4) \approx \frac{1-2}{5-3} = \boxed{\frac{-1}{2}}$$

b. Evaluate $\int_3^{11}(3f'(x)-1)dx$

$$3\int_3^{11} f'(x)\,dx - \int_3^{11} 1\,dx = 3[f(x)]_3^{11} - 8 = 3(9-2) - 8 = 3(7) - 8 = \boxed{13}$$

c. Use a right Riemann sum with 4 subintervals indicated by the table above to approximate the integral. $\int_3^{11} f(x)dx$

$$RRAM = 2(1) + 1(-3) + 3(2) + 2(9)$$
$$= 2 - 3 + 6 + 18 = \boxed{23}$$

d. Use a trapezoidal approximation with 4 subintervals to approximate the integral, $\int_3^{11} f(x)dx$

$$T = \frac{2}{2}(2+1) + \frac{1}{2}(1-3) + \frac{3}{2}(-3+2) + \frac{2}{2}(2+9)$$
$$= 3 - 1 - \frac{3}{2} + 11 = \boxed{\frac{23}{2}}$$

2. Let f be the function defined by $f(x) = ke^x + \ln x$ for $x > 0$, where k is a positive constant.

a. Find $f'(x)$ and $f''(x)$

$$\boxed{f'(x) = ke^x + \frac{1}{x}} \qquad \boxed{f''(x) = ke^x - \frac{1}{x^2}}$$

b. For what value of the constant k does f have a critical point at $x = 1$? For this value of k, determine whether f has a relative minimum, maximum, or neither at $x = 1$. Justify your answer.

$ke^1 + 1 = 0$

$\boxed{k = -1/e}$

$(-\infty, 1): f'(x) > 0$ ∴ f has a max at $x = 1$.

$(1, \infty): f'(x) < 0$

f inc | dec

Test pts:
$x = \frac{1}{2} \quad \frac{-1}{e} \cdot e^{\frac{1}{2}} + \frac{1}{\frac{1}{2}} = $
$x = 2 \quad -\frac{1}{e} \cdot e^2 + \frac{1}{2} = -2$

c. If f has a point of inflection, write an equation for k in terms of x.

$$ke^x - \frac{1}{x^2} = 0$$
$$ke^x = \frac{1}{x^2} \qquad \boxed{k = \frac{1}{x^2 e^x}}$$

3. Repeat #2 with $g(x) = kx^3 + \ln x$

a) $g'(x) = 3kx^2 + \frac{1}{x}$
   $g''(x) = 6kx - \frac{1}{x^2}$

b) $3k + 1 = 0$
   $\boxed{k = -\frac{1}{3}}$

   f' + | -
   f inc | dec

   Test pts: $x = \frac{1}{2} \quad 3(-\frac{1}{3})(\frac{1}{2})^2 + \frac{1}{\frac{1}{2}} \approx \frac{7}{4}$
   $x = 2 \quad 3(-\frac{1}{3})(2)^2 + \frac{1}{2} = -\frac{7}{2}$

   f(x) has a max @ x=1 since for $(-\infty, 1)$ $f'(x) > 0$ and $f'(x) < 0$ for $(1, \infty)$.

c) $6kx - \frac{1}{x^2} = 0$
   $$\frac{6kx}{6x} = \frac{1}{x^2} \cdot \frac{1}{6x}$$
   $$\boxed{k = \frac{1}{6x^3}}$$

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