Assignment #4
Math 1P05
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1. a) $f(t) = t + 2\cos t$, $-2\pi \le t \le 2\pi$

i) domain: $(-2\pi, 2\pi)$

ii) No VA or HA

iii-vi) $f' = 1 - 2\sin t$

$0 = 1 - \sin t$
$-2\sin t = -1$
$\sin t = \frac{1}{2}$

$t = \frac{\pi}{6}$, $t = \frac{5\pi}{6}$, $t = -\frac{11\pi}{6}$, $t = -\frac{7\pi}{6}$

$f'(t)$	$t = -2\pi$	$-2\pi < t < -\frac{11\pi}{6}$	$t = -\frac{11\pi}{6}$	$-\frac{11\pi}{6} < t < -\frac{7\pi}{6}$
Sign	NA	+	0	0
behavior	Min	Inc	Max	Min

$t = -\frac{7\pi}{6}$	$-7\pi/6 < t < \frac{\pi}{6}$	$\frac{\pi}{6}$	$\pi/6 < t < \frac{5\pi}{6}$
0	+	0	—
Min	Inc	Max	Dec

$5\pi/6$	$5\pi/6 < t < 2\pi$	2π
0	+	NA
Min	Inc	Max

$f(-2\pi) = 2\pi + \cos(-2\pi)$
$= -2\pi + 2$
$\therefore$ Minimum $(-2\pi, -2\pi + 2)$

$f(-\frac{11\pi}{6}) = -\frac{11\pi}{6} + 2\cos(-\frac{11\pi}{6})$
$= -\frac{11\pi}{6} + \sqrt{3}$
$\therefore$ Maximum $(-\frac{11\pi}{6}, -\frac{11\pi}{6} + \sqrt{3})$

$f(-\frac{7\pi}{6}) = -\frac{7\pi}{6} + 2\cos(-\frac{7\pi}{6})$
$= -\frac{7\pi}{6} - \sqrt{3}$
$\therefore$ Minimum $(-\frac{7\pi}{6}, -\frac{7\pi}{6} - \sqrt{3})$

$f(\frac{\pi}{6}) = \frac{\pi}{6} + 2\cos(\frac{\pi}{6})$
$= \frac{\pi}{6} + \sqrt{3}$
$\therefore$ Maximum $(\pi/6, \frac{\pi}{6} + \sqrt{3})$

$f(\frac{5\pi}{6}) = \frac{5\pi}{6} + 2\cos(\frac{5\pi}{6})$
$= \frac{5\pi}{6} - \sqrt{3}$
$\therefore$ Minimum $(\frac{5\pi}{6}, \frac{5\pi}{6} - \sqrt{3})$

$\therefore$ Intervals of increasing, $-2\pi < t < -\frac{11\pi}{6}$, $-\frac{7\pi}{6} < t < \frac{\pi}{6}$, $\frac{5\pi}{6} < t < 2\pi$
$\therefore$ Intervals of decrease, $\frac{\pi}{6} < t < \frac{5\pi}{6}$

$f''(t) = -\cos t$
$0 = -\cos t$
$t = \pi/2, \frac{3\pi}{2}, -\frac{3\pi}{2}, -\frac{\pi}{2}$

f''	$-2\pi \leq t \leq -\frac{3\pi}{2}$	$-\frac{3\pi}{2}$	$-\frac{3\pi}{2} \leq t \leq -\frac{\pi}{2}$	$-\frac{\pi}{2}$	$-\frac{\pi}{2} < t < \frac{\pi}{2}$	$\frac{\pi}{2}$
sign	$-$	0	$+$	0	$-$	
behaviour	Concave down	Inflection	Concave UP	Inflection	Concave Down	

$\pi/2$	$\pi/2 < t < \frac{3\pi}{2}$	$3\pi/2$	$3\pi/2 < t \leq 2\pi$
0	+	0	-
Inflection	Concave up	Inflection	Concave Down

$\therefore$ Inflection points $(\pi/2, \pi/2), (-\pi/2, -\pi/2), (\frac{3\pi}{2}, \frac{3\pi}{2}), (-\frac{3\pi}{2}, -\frac{3\pi}{2})$

$\therefore$ Concave Down : $-2\pi \leq t < -\frac{3\pi}{2}$, $\frac{\pi}{2} < t < \pi/2$, $\frac{3\pi}{2} < t \leq 2\pi$

$\therefore$ Concave UP : $-\frac{3\pi}{2} < t < -\frac{\pi}{2}$, $\frac{\pi}{2} < t < \frac{3\pi}{2}$

b) $g(x) = (1+e^x)^{-2}$

i) domain : $(-\infty, \infty)$

ii) No vertical asymptote

$$\lim_{x \to \infty} \frac{1}{(1+e^x)^2}$$

$$= \frac{1}{\lim_{x \to \infty} (1+e^x)^2}$$

$$= 0$$

$$\lim_{x \to -\infty} (1+e^x)^{-2}$$

$$= \left(\lim_{x \to -\infty} (1) + \lim_{x \to -\infty} e^x\right)^{-2}$$

$$= \left(1 + e^{\lim_{x \to -\infty} x}\right)^{-2}$$

$$= -\infty$$

$$\therefore \lim_{x \to -\infty} g(x) = 1$$

$\therefore$ the horizontal asymptotes for $g(x)$ are 0 & 1.

$$g' = -\frac{2}{(1+e^x)^3} \frac{d}{dx}(1+e^x)$$

$$= -\frac{2}{(1+e^x)^3} e^x$$

$$= -\frac{2e^x}{(1+e^x)^3}$$

g'	$-4<x<-1$	$-1<x<4$
sign	$-$	$+$
behaviour	dec	incresing

$\therefore$ Intervals of increse $-1<x<4$

$\therefore$ Intervals of decrease $-4<x<-1$

iv) No local extrema since the Function is asymptotically bound between $y=1$, $y=0$.

v) $g'' = \frac{d}{dx}\left(\frac{-2e^{x}}{(1+e^{x})^3}\right)$

$= -2\frac{d}{dx}\left(\frac{e^{x}}{(1+e^{x})^3}\right)$

$$= -2\,\frac{e^{x}(1+e^{x})^3 - 3(1+e^{x})^2 e^{x}e^{x}}{((1+e^{x})^3)^2}$$

$$= -\frac{2e^{x}(-2e^{x}+1)}{(1+e^{x})^4}$$

$\frac{f(x)}{g(x)} = 0$ $f(x)$

$0 = \square$

$0 = -2e^{x}+1$

$2e^{x} = 1$

$e^{x} = \frac{1}{2}$

$\ln(e^{x}) = \ln(\frac{1}{2})$

$x = \ln(\frac{1}{2})$

$x = -\ln(2)$

g''	$x<-\ln(2)$	$-\ln(2)$	$x>-\ln(2)$
Sign	$-$	0	$+$
behaviour	Concave down	Inflection	Concave up

$\therefore$ The interval for concave down is $x<-\ln(2)$ and the interval for concave up is $x>-\ln(2)$

vi) The inflection point is when $g''(0)=0$
thus the inflection point is $-\ln(2)$.

c) $R(x) = \dfrac{x}{x^3-1}$

i) Domain $(-\infty,1)\cup(1,\infty)$

ii) $VA = x^3-1$
$1 = x^3$
$\therefore$ The vertical asymptote is $x=1$.

$HA=0$ because the numerator is greater than the denominator thus we get $= 0/x^2-1$ which we can't divide.
$\therefore$ HA $y=0$.

iii) $R' = \dfrac{\frac{d}{dx}(x)(x^3-1) - \frac{d}{dx}(x^3-1)x}{(x^3-1)^2}$

$= \dfrac{1(x^3-1) - 3x^2 x}{(x^3-1)^2}$

$R'(x) = \dfrac{-2x^3-1}{(x^3-1)^2}$

$-2x^3 - 1 = 0$

$-2x^3 = 1$

$x^3 = -\dfrac{1}{2}$

$x = -\sqrt[3]{1/2}$

$R'(1) = \text{Undef}$

$x = -\sqrt[3]{1/2}$

R'	$(-\infty, -\sqrt[3]{1/2})$	$(-\sqrt[3]{1/2}, 1)$	$(1, \infty)$
Sign	+	−	−
behaviour	Inc	Dec	Dec

$\therefore$ $R(x)$ is increasing on the interval $(-\infty, -\sqrt[3]{1/2})$ and decreasing over intervals, $(-\sqrt[3]{1/2}, 1), (1, \infty)$.

iv) $x = -\sqrt[3]{1/2}$

$R = \dfrac{-\sqrt[3]{1/2}}{(-\sqrt[3]{1/2})^3 - 1}$

$= \dfrac{2^{\frac{2}{3}}}{3}$

$\therefore$ The local extrema has a maximum $(-\sqrt[3]{1/2}, 2^{2/3}/3)$

v) $R'(x) = \dfrac{-2x^3-1}{(x^3-1)^2}$

$$R''(x) = \frac{\frac{d}{dx}(-2x^3-1)(x^3-1)^2 - \frac{d}{dx}((x^3-1)^2) -2x^3-1}{((x^3-1)^2)^2}$$

$$= \frac{-6x^2(x^3-1)^2 - 6x^2(x^3-1)(-2x^3-1)}{((x^3-1)^2)^2}$$

$$= -\frac{6x^2\cancel{(x^3-1)}(-x^3-2)}{(x^3-1)^{\cancel{4}}}$$

$$R'' = -\frac{6x^2(-x^3-2)}{(x^3-1)^3}$$

$6x^2(-x^3-2) = 0$

$-6x^2(x+\sqrt[3]{2})(x^2-\sqrt[3]{2}x+2^{\frac{2}{3}}) = 0$

$x+\sqrt[3]{2} = 0$ $\qquad x = 0, x = 1$

$x = -\sqrt[3]{2}$

R''	$(-\infty, -\sqrt[3]{2})$	$(-\sqrt[3]{2}, 0)$	$(0, 1)$	$(1, \infty)$
sign	+	−	−	+
behaviour	CU	CD	CD	CU

$\therefore$ The interval for concave up is $(-\infty, -\sqrt[3]{2})$ and $(1, \infty)$. Interval for concave down is $(-\sqrt[3]{2}, 0)$ and $(0, 1)$.

vi) $R''(-\sqrt[3]{2}) = 0$

$$R(-\sqrt[3]{2}) = \frac{-\sqrt[3]{2}}{(-\sqrt[3]{2})^3 - 1}$$

$$= \frac{\sqrt[3]{2}}{3}$$

∴ The inflection point for $R(x)$ is $(-\sqrt[3]{2}, \sqrt[3]{2}/3)$.

2. 4.4 #38

$$= \lim_{x \to 0} \frac{x^2 \sin x}{\sin x - x}$$

$$= \frac{0}{0}$$

* LHR

$$= \lim_{x \to 0} \frac{\frac{d}{dx}(x^2 \sin x)}{\frac{d}{dx}(\sin x - x)}$$

$$= \lim_{x \to 0} \frac{2x \sin x + \cos x \, x^2}{\cos x - 1}$$

$$= \frac{2(0)\sin(0) + \cos x \, x^2}{\cos(0) - 1} = \frac{0}{0}$$

$\frac{d}{dx} 2x \sin x + \frac{d}{dx} \cos x \, x^2$

$2\sin x + 2x\cos x - x^2 \sin x$
$+ 2x \cos$

* LHR

$$= \lim_{x \to 0} \frac{\frac{d}{dx}(2x \sin x + \cos x \, x^2)}{\frac{d}{dx}(\cos x - 1)}$$

$$= \lim_{x \to 0} \frac{-x^2 \sin x + 4x \cos + 2 \sin x}{-\sin x}$$

$$= \frac{-(0)^2 \sin(0) + 4(0) \cos + 2 \sin(0)}{-\sin(0)} = \frac{0}{0}$$

LHR

$$\lim_{x \to 0} \frac{d/dx\left(-x^2 \sin x + 4x\cos + 2\sin x\right)}{d/dx\left(-\sin x\right)}$$

$$\lim_{x \to 0} \frac{\frac{d}{dx}\left(x^2 \sin x\right) - \frac{d}{dx}\left(4x\cos\right) - d/dx\left(2\sin x\right)}{d/dx\left(\sin x\right)}$$

$$= \lim_{x \to 0} \frac{2x\sin + \cos x x^2 - \left(4\cos x - 4x\sin x\right) - 2\cos x}{\cos x}$$

$$= 2x\sin x + \cos x x^2 - 4\cos x + 4x\sin x - 2\cos x$$

$$= x^2\cos x + 2x\sin x + 4x\sin x - 6\cos x$$

$$= x^2\cos x + 6x\sin x - 6\cos x$$

$$\lim x \to 0 \quad \frac{x^2\cos x + 6x\sin x - 6\cos x}{\cos x}$$

$$= \frac{(0)^2\cos(0) + 6(0)\sin(0) - 6\cos(0)}{\cos(0)}$$

$$= \frac{-6}{1} = -6$$

$$\therefore \lim_{x \to 0} \frac{x^2 \sin x}{\sin x - x} = -6$$ using LHR.

3) 4.4 #46

$$\lim_{x \to -\infty} x \ln\left(1 - \frac{1}{x}\right) = \infty \cdot 0$$

Indeterminate

* LHR

$$\lim_{x \to -\infty} \frac{d/dx \ln(1 - 1/x)}{d/dx \; 1/x}$$

$$\lim_{x \to -\infty} \frac{\frac{1}{x(x-1)}}{-1/x^2} = \quad = \frac{1 \cdot x^2}{x(x-1) \cdot 1} = -\frac{x^2}{x(x-1)} = -\frac{-x}{x-1}$$

$$= \lim_{x \to -\infty} \frac{-x}{x-1}$$

* LHR

$$\lim_{x \to -\infty} \frac{d/dx \; -x}{d/dx (x-1)}$$

$$\lim_{x \to -\infty} \left(\frac{-1}{1}\right)$$

$$= -1$$

$\therefore$ The $\lim_{x \to -\infty} x \ln\left(1 - \frac{1}{x}\right) = -1.$

4) 4.4 # 62

$$\lim_{x\to\infty} (e^x + 10x)^{1/x}$$

$$\lim_{x\to\infty} e^{\frac{1}{x}\ln(e^x+10x)}$$

$g(x) = 1/x \ln(e^x + 10x)$ $\qquad f(u) = e^u$

$$\lim_{x\to\infty} \frac{1}{x} \ln(e^x + 10x)$$

$$\lim_{x\to\infty} \frac{\ln e^x + 10x}{x}$$

$$= \frac{\infty}{\infty}$$

$$\frac{1}{e^x+10x} \, d/dx(e^x+10x)$$

$$= \frac{1}{e^x+10x} \, e^x + 10$$

$$= \frac{e^x+10}{e^x+10x}$$

* LHR

$$\lim_{x\to\infty} \frac{\frac{d}{dx} \ln e^x + 10x}{d/dx \; x}$$

$$\lim_{x\to\infty} \frac{\frac{e^x+10}{e^x+10x}}{1}$$

$$\lim_{x\to\infty} \frac{e^x}{e^x+10} = \frac{\infty}{\infty}$$

* LHR

$$\lim_{x\to\infty} \frac{d/dx \; e^x}{d/dx(e^x+10)}$$

$$\lim_{x\to\infty} \frac{e^x}{e^x} = 1$$

$$\lim_{x\to\infty} 1 = 1$$

$$\lim_{u\to 1} e^u = e^1 = e$$

$\therefore$ The $\lim_{x\to\infty} (e^x+10x)^{1/x} = e$ using LHR.

5. 4.4 #74

$f(x) = 2x\sin x$, $g(x) = \sec x - 1$

$$\lim_{x\to 0} \frac{f(x)}{g(x)} = \lim_{x\to 0} \frac{2x\sin x}{\sec x - 1}$$

$$= \frac{0}{0}$$

* LHR

$$2 \cdot \lim_{x\to 0} \frac{\frac{d}{dx}(x\sin x)}{\frac{d}{dx}(\sec x - 1)}$$

$$2 \cdot \lim_{x\to 0} \frac{\sin x + x\cos x}{\sec x\tan x}$$

$$= \frac{0}{0}$$

* LHR

$$2 \cdot \lim_{x\to 0} \frac{\frac{d}{dx}(\sin x + x\cos x)}{\frac{d}{dx}(\sec x\tan x)}$$

$\frac{d}{dx}(\sec x)\tan x + \frac{d}{dx}(\tan x)\sec x$

$= \sec x\tan x\tan x + \sec^2 x \sec x$

$= -\sec x + 2\sec^3 x$

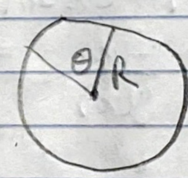
$$= 2 \cdot \lim_{x \to 0} \left(\frac{2\cos x - x\sin x}{-\sec x + 2\sec^3 x} \right)$$

$$= 2 \cdot \left(\frac{2\cos(0) - (0)\sin(0)}{-\sec(0) + 2\sec^3(0)} \right)$$

$$= 4$$

$\therefore$ The $\lim_{x \to 0} \frac{f(x)}{g(x)} = 4$ using LHR.

7. Perimeter of sector $= 16m$



$P = 16m$

$R = ?$

$P = 2r + \theta r$

$2r + \theta r = 16 \qquad A = \frac{1}{2} r^2 \theta$

$\theta = \frac{16}{r} - 2$

$$A = \frac{1}{2} r^2 \left(\frac{16}{r} - 2 \right)$$

$$= \frac{1}{2} 16r - 2r^2$$

$$= 8r - r^2$$

$$A' = \frac{d}{dx}(8r - r^2)$$

$$= 8 - 2r$$

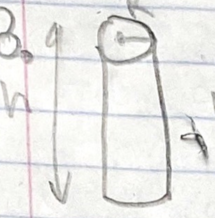
$$0 = 8 - 2r$$

$$r = 4m$$

$\therefore$ The largest burning radius of the circle is $4m$, $r = 4m$.

$750 = \pi r^2 h$

$h = \frac{750}{\pi r^2}$

8. 

$V = 750\,m^3$ $\quad V = \pi r^2 h$

$m = 1.5$ $\quad S = 2\pi r h + 2\pi r^2$

$L = 2(2\pi r) + h$

$s = 0.45$ $\quad = 4\pi r + h$

$Cost = S(1.5) + L(0.45)$

$= (2\pi r h + 2\pi r^2)(1.5) + (4\pi r + h)(0.45)$

$= 1.5(2\pi r(\frac{750}{\pi r^2}) + 2\pi r^2) + (4\pi r + (\frac{750}{\pi r^2}))0.45$

$C = \frac{2250}{r} + 3\pi r^2 + 1.8\pi r + \frac{337.5}{\pi r}$

9. a) $f(x) = 2\cos x - \sqrt{e^{2x}}$ $\qquad \sqrt{e^{x}}$

$= \int 2\cos x - \sqrt{e^{2x}}\ d/dx$ $\qquad e^{\frac{2x}{2}}$

$= \int 2\cos x\ d/dx - \int \sqrt{e^{2x}}\ d/dx$ $\qquad e^{x}$

$= 2\sin x - e^{x} + C$

$F(x) = 2\sin x - e^{x} + C$

$\frac{d}{dx} F(x) = \frac{d}{dx}(2\sin x - e^{x} + C)$

$F(x) = 2\cos x - e^{x}$

$\therefore$ The $\int F(x)\ d/dx = 2\sin x - e^{x} + C$ and differentiating $F(x)$, $F'(x) = 2\cos x - e^{x}$

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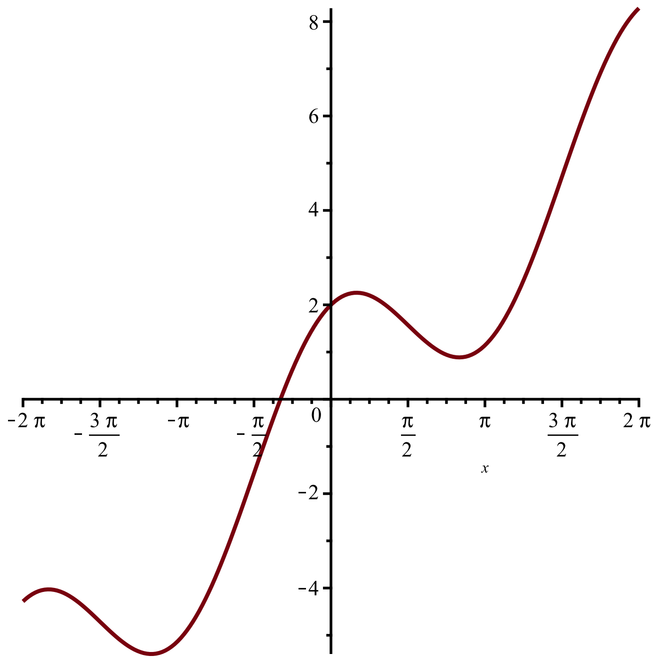
> $f := x + 2\cos(x);$

$$f := x + 2\cos(x) \quad (1)$$

> $plot(f);$



Min values are $(-2\pi, -2\pi + 2)$, $(-7\pi/6, -7\pi/6 - \sqrt{3})$, $(5\pi/6, 5\pi/6 - \sqrt{3})$

Max Values are $(-11\pi/6, -11\pi/6 + \sqrt{3})$, $(\frac{\pi}{6}, \frac{\pi}{6} + \sqrt{3})$

Intervals of increase $-2\pi < t < \frac{-11\pi}{6}$, $\frac{-7\pi}{6} < t < \frac{\pi}{6}$, $\frac{5\pi}{6} < t < 2\pi$

Intervals of decrease $\frac{\pi}{6} < t < \frac{5\pi}{6}$

Inflection Points $(\frac{\pi}{2}, \frac{\pi}{2})$, $(-\frac{\pi}{2}, -\frac{\pi}{2})$, $(\frac{3\pi}{2}, \frac{3\pi}{2})$, $(-\frac{3\pi}{2}, -\frac{3\pi}{2})$

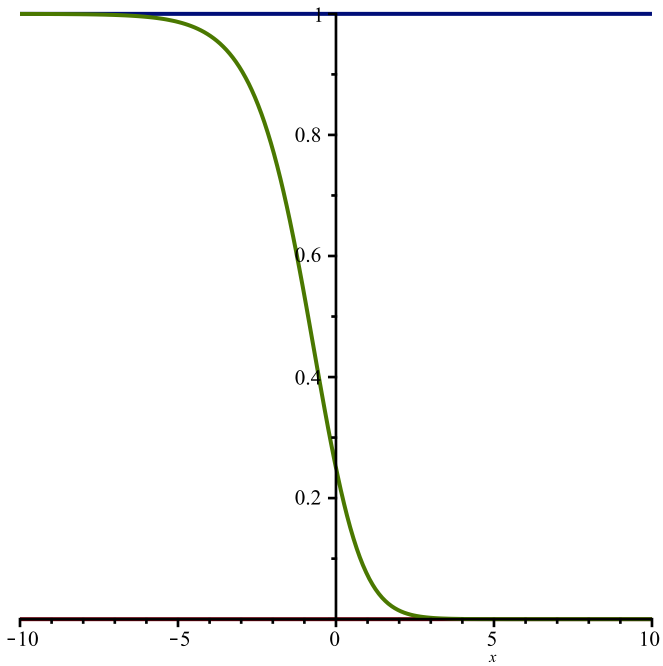
Concave Down $(-2\pi, -\frac{3\pi}{2})$, $(\frac{\pi}{2}, \frac{3\pi}{2})$

Concave Up $(-\frac{3\pi}{2}, -\frac{\pi}{2})$, $(\frac{\pi}{2}, \frac{3\pi}{2})$

> $g := (1 + e^{x})^{-2};$

$$g := \frac{1}{(1 + e^{x})^{2}} \quad (2)$$

> $plot(\{g, (1), (0)\});$

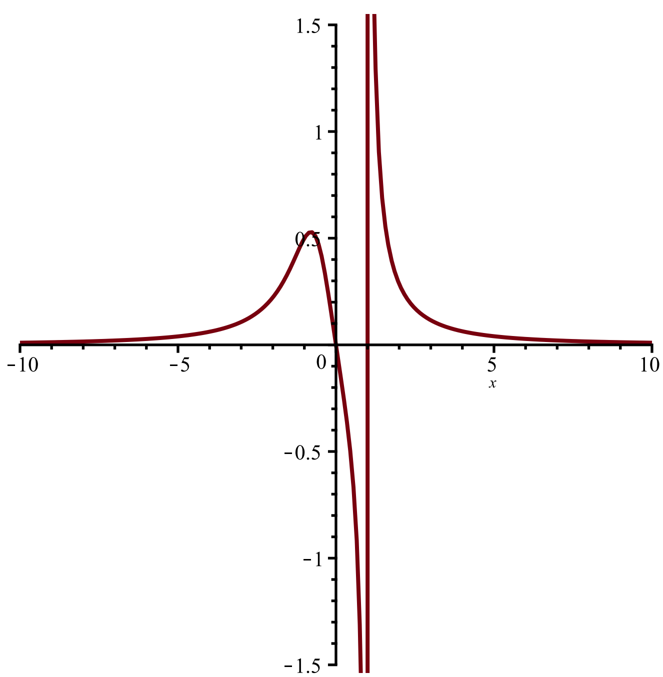


Horizontal asymptotes y = 0, y = 1
Intervals of increase -1 < x < 4
Intervals of decrease -4 < x < -1
Concave down x < -ln(2)
Concave up x > -ln(2)
Inflection point -ln(2)

> $R := \frac{x}{x^3 - 1};$

$$R := \frac{x}{x^3 - 1} \tag{3}$$

> $plot(R);$



Vertical Asymptote x = 1

Interval of increase -inf < x < $-\sqrt[3]{\frac{1}{2}}$

Interval of decrease $-\sqrt[3]{\frac{1}{2}} < x < 1, 1 < x < \inf$

Local Extrema $\left(-\sqrt[3]{\frac{1}{2}}, \frac{2^{\frac{2}{3}}}{3}\right)$

Concave Up -inf < x < $-\sqrt[3]{2}$, $1 < x <$ infinity

Concave Down $-\sqrt[3]{2} < x < 0, 0 < x < 1$

Inflection point $\left(-\sqrt[3]{2}, \frac{\sqrt[3]{2}}{3}\right)$

Error, mismatched or missing bracket/operator

$$\boxed{\sqrt[3]{\frac{1}{2}} < x < 1, \ 1 < x < inf Local \ Extrema \ (}$$

Error, mismatched or missing bracket/operator

$$\boxed{\sqrt[3]{\frac{1}{2}}, \frac{2^{\frac{2}{3}}}{3})}$$

$$2^{1/3}, 1 < x < \infty \ Concave \, Down$$

Error, mismatched or missing bracket/operator

$$\boxed{\sqrt[3]{2} < x < 0, \ 0 < x < 1 \ Inflection \ point \ (}$$

Error, mismatched or missing bracket/operator

$$\boxed{\sqrt[3]{2}, \frac{\sqrt[3]{2}}{3})}$$

6.)

> $AB := \sqrt{x^2 + 3.2^2};$
$BC := 12 - x;$
$Total := \frac{AB}{4} + \frac{BC}{6};$

$$AB := \sqrt{x^2 + 10.24}$$
$$BC := 12 - x$$
$$Total := \frac{\sqrt{x^2 + 10.24}}{4} + 2 - \frac{x}{6} \quad (4)$$

> $TT := diff(Total, x);$
$TT = 0;$

$$TT := \frac{x}{4\sqrt{x^2 + 10.24}} - \frac{1}{6}$$

(5)

$$\frac{x}{4\sqrt{x^2+10.24}}-\frac{1}{6}=0 \tag{5}$$

> $fsolve(\%, x);$

$$2.862167011 \tag{6}$$

Therefore, the hiker must aim at a point that is 2.862km ahead of the road from point P towards the restaurant.

8)

> $c := \frac{2250}{r} + 3\ \mathrm{pi}\ r^2 + 1.8\ \mathrm{pi}\ r + \frac{337.5}{\mathrm{pi}\ r^2};$

$$c := \frac{2250}{r} + 3\pi r^2 + 1.8\pi r + \frac{337.5}{\pi r^2} \tag{7}$$

> $C := diff(c, r);$

$$C := -\frac{2250}{r^2} + 6\pi r + 1.8\pi - \frac{675.0}{\pi r^3} \tag{8}$$

> $C = 0$

$$-\frac{2250}{r^2} + 6\pi r + 1.8\pi - \frac{675.0}{\pi r^3} = 0 \tag{9}$$

> $evalf(\%);$

$$-\frac{2250.}{r^2} + 6.\pi r + 1.8\pi - \frac{675.0}{\pi r^3} = 0. \tag{10}$$

> $h := \frac{750}{\pi(4.8)^2};$
> $fsolve(h);$

$$h := \frac{750}{\pi(4.8)^2} \tag{11}$$

> $cc := subs(r = 4.8, c);$

$$cc := 468.7499999 + 77.76\pi + \frac{14.64843750}{\pi} \tag{12}$$

Therefore, Radius is 4.8m height is $\frac{750}{\pi(4.8)^2}$ m, minimum cost is cc which is $468.7499999 + 77.76\pi + \frac{14.64843750}{\pi}$ \$. $(r = 4.8\ m, h = 10.2\ m, cost = \$717.60)$

>