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Lesson 1 - Oct 11, 2025

Part 1: Math Review

Limit Formula: $\lim_{x \to 2} x^2 = 4$

Average speed formula: $\frac{\text{distanced travelled}}{\text{time taken}}$

Power rule for derivatives: $\frac{d}{dx}(x^n) = nx^{n-1}$

Exercise 1 (f, l, b, g)

f) $x^2 + x \rightarrow x^1 + x^{-1}$

Step 1: $f(x) = x^2 + x$ has two terms, so we differentiate each one:

I. Derivative of x^2: $\frac{d}{dx}(x^2) = 2x^{2-1} = 2x$

II. Derivative of x: $\frac{d}{dx}(x^1) = 1x^{1-1} = 1$

III. Add together $2x + 1$

Final answer: $f'(x) = 2x + 1$

l) $\frac{x^3+5}{x} \rightarrow f(x) = \frac{x^3}{x} + \frac{5}{x} \rightarrow x^2 + 5x^{-1}$

x^2: $\frac{d}{dx}(x^2) = 2x^{2-1} = 2x$

$5x^{-1}$: $\frac{d}{dx}(x^2) = 5(-1)x^{-2} = -5x^{-2}$

Final answer: $f'(x) = 2x - \frac{5}{x^2}$

b) $\sqrt[3]{x} \rightarrow x^{\frac{1}{3}}$

$x^{\frac{1}{3}}$: $\frac{d}{dx}(x^{1/3}) \rightarrow \frac{1}{3}x^{\frac{1}{3}-1} = \frac{1}{3} - 1 = -\frac{2}{3} \rightarrow f'(x) = \frac{1}{3}x^{-\frac{2}{3}}$

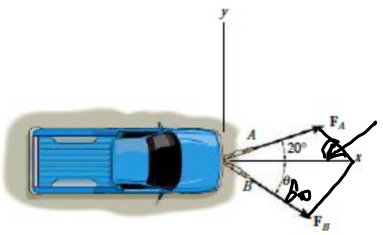
Final answer: $f'(x) = \frac{1}{3x^{\frac{2}{3}}}$

g) $\frac{5}{x^2\sqrt{x}} \rightarrow \sqrt{x} = x^{\frac{1}{2}} \rightarrow x^2\sqrt{x} = x^{2+1/2} = x^{5/2} \rightarrow f(x) = 5x^{-5/2}$

$f'(x) = 5 \cdot (-\frac{5}{2})x^{-5/2-1} \rightarrow f'(x) = -\frac{25}{2}x^{-7/2}$

Final answer: $f'(x) = -\frac{25}{2x^3\sqrt{x}}$

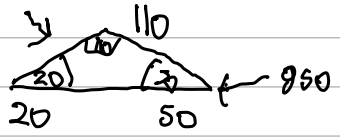
2–14. The truck is to be towed using two ropes. Determine the magnitude of forces $\mathbf{F}_A$ and $\mathbf{F}_B$ acting on each rope in order to develop a resultant force of 950 N directed along the positive x axis. Set $\theta = 50°$.



Prob. 2–14

Answer:

- $F_A \approx 744.45$ N
- $F_b \approx 345.77$ N



$\frac{a}{\sin a} = \frac{b}{\sin b}$

$\frac{Fa}{\sin 20} = \frac{950}{\sin 110}$

Exercise 2

3. According to Wikipedia, the 2006 Renault R26) accelerates at the following rates:
   - 0 to 100 km/h : 1.7 seconds
   - 0 to 200 km/h: 3.8 seconds
   - 0 to 300 km/h: 8.6 seconds

   Compute the average accelerations of this car as it goes from 0 to 100 km/hr, from 100 km/hr to 200 km/hr and from 200 km/hr to 300km/hr. Provide your answer in SI units.
   In each case, how many g's does the driver experience? ($1\,g = 9.8\,m/s^2$)

4. An object is dropped from a certain height and hits the ground with speed 20 m/s.
   a) From what height was it dropped? b) How fast is it going when it is 5m from ground?

3. (1) We are given:

- $0 \to 100$ Km/h in 1.7s
- $0 \to 200$ Km/h in 3.8s
- $0 \to 300$ Km/h in 8.6s
- $1g = 9.8\,m/s^2$

(2) Convert speeds

- $100\,Km/h = 100 \cdot \frac{1000}{3600} = 27.78\,m/s$
- $200\,Km/h = 200 \cdot \frac{1000}{3600} = 55.56\,m/s$
- $300\,Km/h = 300 \cdot \frac{1000}{3600} = 83.33\,m/s$

(3) interval $0 \to 100$ Km/h

$a = \frac{v-u}{t} = \frac{27.78-0}{1.7\,s}$

$a \approx 16.34\ m/s^2$

In g's: $\frac{16.34}{9.8} \approx 1.67g$

(4) Answer

Avg acceleration:

$a_{0-100} = 16.34\,m/s^2 \approx 1.67g$

(5) Interval $100 \to 200$ Km/h

$\Delta t = 3.8 - 1.7 = 2.1s$

$a = \frac{55.56 - 27.78}{2.1}$

$a \approx 13.26\ m/s^2$

In g's: $\frac{13.26}{9.8} \approx 1.35g$

Answer: Avg acceleration $a_{100-200}$ $13.26\,m/s^2$ ($\approx 1.35g$)

(6) Interval $200 \to 300$ Km/h

$\Delta t = 8.6 - 3.8 = 4.8s$

$a = \frac{83.33 - 55.56}{4.8} \approx 5.79\,m/s^2$

Answer: $5.79\,m/s^2$ ($\approx 0.59g$)

(7) Final Answer:

Interval	Speed Change	Time	Acceleration	g's
$0 \to 100$ Km/h	$0 \to 27.78$	1.7s	16.34	1.67g
$100 \to 200$ Km/h	$27.78 \to 55.56$	2.1	13.26	1.35g
$200 \to 300$ Km/h	$55.56 \to 83.33$	4.8	5.79	0.59g

4. Using Kinetic equation: $v^2 = u^2 + 2gh$

(a) From what height was it drop?

$(20)^2 = 0 + 2(9.8)h$

$400 = 19.6h$

$h = \frac{400}{19.6}$

$h \approx 20.41m$

height $\approx 20.41m$

(b) How fast is it going 5m from the ground?

$20.41 - 5 = 15.41m$

$v^2 = 0 + 2(9.8)(15.41)$

$v^2 \approx 301.036$

$v \approx \sqrt{301.036} \approx 17.36\,m/s$

Final Answer:

(a) 20.4m

(b) 17.4 m/s