$s(t) = t^4 - 6t^3 + 12t^2 + 3$

22. find t such that $v(t) = 0$
$s'(t) = 0$

23. t such that $a(t) > 0$
$v'(t) > 0$ $s''(t) > 0$

24. speed $= |v(t)|$
speed increases when $v(t)$ & $a(t)$ are either both positive or both negative

$s(t) = t^4 - 6t^3 + 12t^2 + 3$

22. $v(t) = s'(t) = 4t^3 - 18t^2 + 24t$

$t = \frac{-(-9) \pm \sqrt{81 - 4(2)(12)}}{2(2)}$ $0 = 2t(2t^2 - 9t + 12)$

no real $t = 0$

23. $a(t) = v'(t) = s''(t) = 12t^2 - 36t + 24$

$12(t^2 - 3t + 2) > 0$

$(t-2)(t-1) > 0$

1 2

$t < 1$ or $t > 2$

24. $a(t)>0$ for $t<1$ and $t>2$

$v(t)>0$?

$2t(2t^2-9t+12)>0$

$v(t)$ $\overset{-}{\underset{t=-1}{|}}\overset{+}{\underset{t=1}{|}}$

$a(t)$ $+\ 0\ +\ -\ +$ with zeros at $0, 1, 2$

$0<t<1$ & $t>2$

edge ranges from 9.9 to 10.1

volume ranges from 9.9^3 to 10.1^3

$\frac{10.1-10}{10} = \frac{0.1}{10} = 0.01 = 1\%$

$\frac{10.1^3-10^3}{10^3} = \frac{10.1^3}{10^3} - 1$ $\quad -1$

$\frac{(10+\frac{1}{10})^3}{10^3} - 1 = \frac{10^3+3(10)^2(\frac{1}{10})+3(10)(\frac{1}{10})^2+(\frac{1}{10})^3}{10^3} - 1$

$\frac{1000+30+0.3+0.001}{1000}$

$\frac{1030.301}{1000} - 1 = 1.030301 - 1$

$= 0.030301 \approx 3\%$

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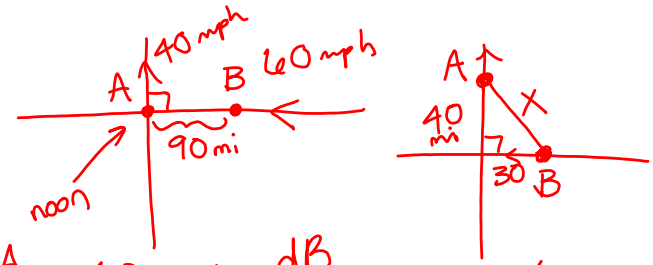

$\frac{dA}{dt} = 40$ mi/h ; $\frac{dB}{dt} = -60$ mi/h

$\frac{dx}{dt} = ?$ when $t = 1$

$A^2 + B^2 = X^2$

$2A \cdot \frac{dA}{dt} + 2B \cdot \frac{dB}{dt} = 2X \cdot \frac{dx}{dt}$

$\frac{2A\frac{dA}{dt} + 2B\frac{dB}{dt}}{2X} = \frac{dx}{dt}$

$\frac{40(40) + 30(-60)}{50} = \frac{1600 - 1800}{50} = \frac{-200}{50} = -4$

83 minimize X

$A^2 + B^2 = X^2$

$\frac{dA}{dt} = 40$

solve $\frac{dx}{dt} = 0$

$\frac{dB}{dt} = -60$

$\frac{dx}{dt} = \frac{A \cdot \frac{dA}{dt} + B\frac{dB}{dt}}{X} = 0$

$40A - 60B = 0$

$40A = 60B$

$A = \frac{3B}{2}$

$A(t) = 40t$

$B(t) = -60t + 90$

Since $\frac{dx}{dt} = 0$ when $A = \frac{3}{2}B$,

$40t = \frac{3}{2}(-60t + 90)$

$40t = -90t + 135$

$130t = 135$

$\boxed{t = \frac{27}{26}}$

$x(t) = \sqrt{(40t)^2 + (-60t + 90)^2}$

$x'(t) = \frac{2(40t)(40) + 2(-60t + 90)(-60)}{2\sqrt{(40t)^2 + (-60t + 90)^2}}$

$2(40t)(40) + 2(-60t + 90)(-60) = 0$

$3200t - 120(-60t + 90) = 0$

$3200t + 7200t - 10800 = 0$

$10400t = 10800$

$\boxed{t = \frac{27}{26}}$