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This is a 3-D problem involving instantaneous velocity.

The position of a particle is given by  $\vec{r} = 4\hat{i} - 2t^2\hat{j} + 8t^3\hat{k}$ ,

(a) What is the instantaneous velocity of the particle at  $t = 2.0\text{s}$ ?

(b) What is the magnitude of the instantaneous velocity at  $t = 2.0\text{s}$ ?

with  $\vec{r}$  in meters, and  $t$  in seconds.

Solution:

(a) Instantaneous velocity,  $\vec{v} = \frac{dx}{dt}\hat{i} + \frac{dy}{dt}\hat{j} + \frac{dz}{dt}\hat{k}$

$$\frac{dx}{dt} = \frac{d(4)}{dt} = 0$$

$$\frac{dy}{dt} = \frac{d(-2t^2)}{dt} = -4t$$

$$\frac{dz}{dt} = \frac{d(8t^3)}{dt} = 24t^2$$

$$\text{at } t = 2.0\text{s}, \frac{dx}{dt} = 0, \frac{dy}{dt} = -4(2) = -8, \frac{dz}{dt} = 24(2)^2 = 96$$

(units in  $\text{m/s}$ )

$$\vec{v} = -8\hat{j} + 96\hat{k} \text{ (answer)}$$

$$(b) |\vec{v}| = \sqrt{(-8)^2 + (96)^2} = 96.3 \text{ m/s (answer)}$$