“Quarks, neutrinos, mesons. All those damn particles you can’t see. That’s what drove me to drink. But now I can see them!”
Motion in One Dimension

- **Reference Frame**
  - $v_{Train} = 85 \text{km/h}$, $v_{Person} = 5 \text{km/h}$
  - $v_{Total} = 90 \text{km/h}$

- **Displacement-Distance**
  - Distance an object traveled
  - Displacement: Change in Object Position
  - Scalar – Vector in 1-d and 2-d
Velocity - Speed

- Average Velocity = displacement / elapsed time
- Average Speed = distance / elapsed time
- Note: displacement-vector, time-scalar \(\Rightarrow\) velocity-vector
- Always:
  - vector \(\times\) or / scalar = vector
  - scalar \(\times\) or / scalar = scalar

- Though this is sloppy: \(v = \frac{x}{t}\)
Instantaneous Velocity

\[ v = \lim_{\Delta t \to 0} \Delta x / \Delta t = \frac{dx}{dt} \]

\( \Delta t \neq 0 \), because if \( \Delta t = 0 \), then \( \Delta x = 0 \) \( \Rightarrow \) \( 0/0 = ? \)
Average Acceleration

Average acceleration = change of v/elapsed time
0 to 75km/h in 5s
Avg. accel. = ?
Average Acceleration

- Average acceleration = change of $v$/elapsed time
- 0 to 75km/h in 5s
- Avg. accel. = ?

\[ \Delta v = 75 \text{km/h} - 0 \text{km/h} \]
\[ \Delta t = 5 \text{s} \]
\[ \frac{\Delta v}{\Delta t} = \frac{75 \text{km/h}}{5 \text{s}} = 15 \text{km/h/s} = 4.2 \text{m/s}^2 \]
Instantaneous Acceleration

\[ a = \lim_{\Delta t \to 0} \frac{\Delta v}{\Delta t} = \frac{dv}{dt} = \frac{d^2x}{dt^2} \]
An Example

- Particle moving: $x = (2.10 \text{m/s}^2)t^2 + 2.80 \text{m}$
- Velocity, Acceleration
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![Graphs](attachment:graph.png)
An Example

- Particle moving: \( x = (2.10 \text{m/s}^2)t^2 + 2.80 \text{m} \)
- Velocity, Acceleration
- \( v = \frac{dx}{dt} = (4.20 \text{m/s}^2)t \)
- \( a = \frac{dv}{dt} = 4.20 \text{m/s}^2 \)
Calculus – a practical overview

\[ x = C t^n \Rightarrow v = \frac{dx}{dt} = n C t^{n-1} \Rightarrow \]
\[ a = \frac{dv}{dt} = \frac{d^2x}{dt^2} = n(n-1) C t^{n-2} \]

<table>
<thead>
<tr>
<th>( x = )</th>
<th>( v = )</th>
<th>( a = )</th>
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<tbody>
<tr>
<td>C</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>( At + C )</td>
<td>A</td>
<td>0</td>
</tr>
<tr>
<td>( Bt^2 + At + C )</td>
<td>( 2Bt + A )</td>
<td>( 2B )</td>
</tr>
<tr>
<td>( R t^4 - S t^2 + T )</td>
<td>( ... )</td>
<td>( ... )</td>
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