Compute the normalization constant C.

$$
\begin{aligned}
C &= \int_{x_a}^{x_b} P(b)\, dx \\
&= \frac{m}{2\pi\hbar(t_b - t_a)}\, x\Big|_{x_a}^{x_b} \\
&= \frac{m}{2\pi\hbar}\left(\frac{x_b - x_a}{t_b - t_a}\right)
\end{aligned}
$$

From $v = (x_b - x_a)/(t_b - t_a)$ and $p = mv$ we have

$$
C = \frac{p}{2\pi\hbar}
$$

Hence diverging normalization C corresponds to unrestricted momentum p.

From $v = p/m$ we have

$$
\frac{x_b - x_a}{t_b - t_a} + \frac{dx}{t_b - t_a} = \frac{p}{m} + \frac{dp}{m}
$$

It follows that

$$
dx = \frac{dp}{m}(t_b - t_a)
$$

Multiply both sides by $P(b)$.

$$
P(b)\, dx = \frac{dp}{2\pi\hbar}
$$