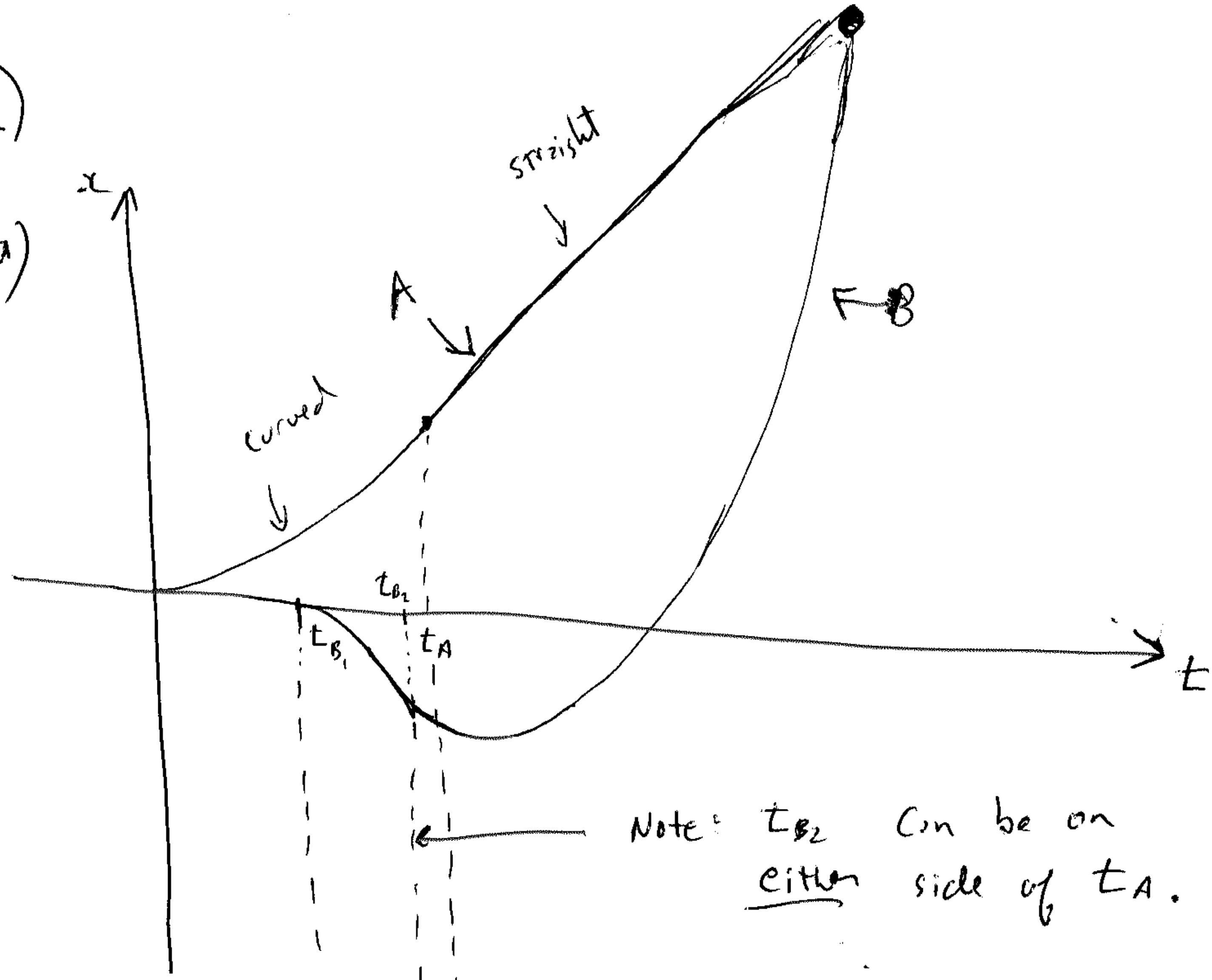
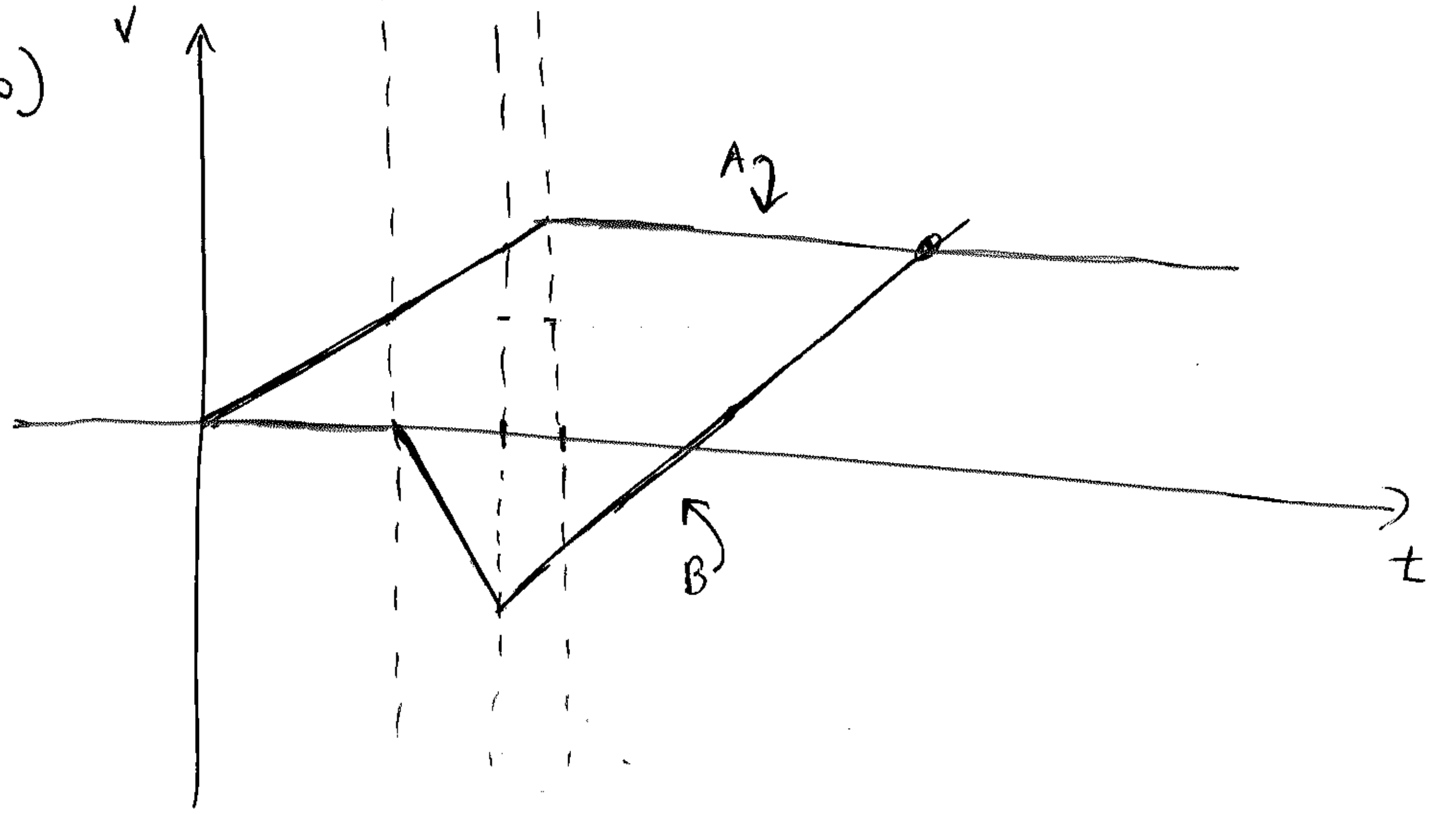
1)

a)


x
straight
A
B
curved
t_{B_2}
t_{B_1}
t_A
t
Note: t_{B_2} can be on either side of t_A.

b)


v
A
B
t

1b Calculate separation at time t_{B_2}

strategy: Calculate how far A moves (abs. value)

Calculate how far B moves (abs. value)

Add the two

Key Equation $\Delta x = V_i \Delta t + \frac{1}{2} a (\Delta t)^2$

Δt_A = time A is traveling $= t$

Δt_B = time B is traveling $= t - t_{B_1}$

~~Note: In~~

Particle A: During acceleration phase:

$$\Delta x_{A_1} = \frac{1}{2} a_A (t_A)^2$$

During constant velocity phase:

$$\Delta x_{A_2} = V_{t_A} \Delta t = V_{t_A} (t - t_A)$$

$$V_{t_A} = \underbrace{\cancel{V_{A_i}}}_{0} + a_A t_A = a_A t_A$$

so $\Delta x_A = \Delta x_{A_1} + \Delta x_{A_2} = \frac{1}{2} a_A t_A^2 + a_A t_A (t - t_A)$

PARTICLE B:

$$\Delta x_B = -\frac{1}{2} a_B (t - t_{B_1})^2$$

$t = t_{B_2}$ according to question so

Sep. dist $= |\Delta x_A| + |\Delta x_B|$

$$\boxed{= \frac{1}{2} a_A t_A^2 + a_A t_A (t_{B_2} - t_A) + \frac{1}{2} a_B (t_{B_2} - t_{B_1})^2}$$

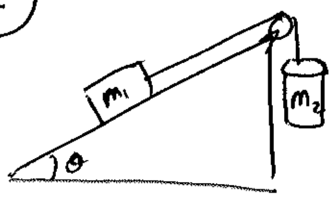
Note: If $t_{B_2} < t_A$ (like in my part a)

then ANSWER WOULD BE

$$\boxed{\frac{1}{2} a_A (t_{B_2})^2 + \frac{1}{2} a_B (t_{B_2} - t_{B_1})^2}$$

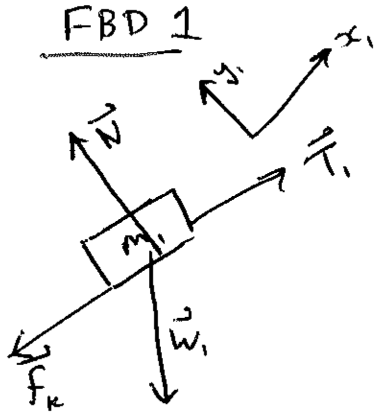
whichever ANSWER AGREES WITH your graph is OK

(2)

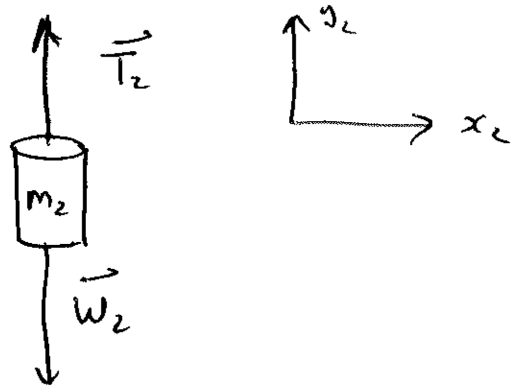


I'll Assume block moves <u>up</u> the ramp

FBD 1



FBD 2



Newton's Laws:

(i) $\sum F_{x_1} = +|\vec{T}_1| - |\vec{f}_k| - |\vec{W}_1|\sin\theta = m_1 a_{1x}$

(ii) $\sum F_{y_1} = +|\vec{N}| - |\vec{W}_1|\cos\theta = 0$

(iii) $\sum F_{x_2} = 0$ Trivial

(iv) $\sum F_{y_2} = +|\vec{T}_2| - |\vec{W}_2| = m_2 a_{2y}$

Some physics:

$|\vec{T}_1| = |\vec{T}_2|$, $a_{1x} = -a_{2y}$

$|\vec{W}_1| = m_1 g$, $|\vec{W}_2| = m_2 g$

$|\vec{f}_k| = \mu_k |\vec{N}|$

Eq (ii) gives: $|\vec{N}| = m_1 g \cos\theta$

so $|\vec{f}_k| = \underline{\mu_k m_1 g \cos\theta}$

3

$$\frac{Eq\ (iv)}{m_2} + \frac{Eq\ (i)}{m_1} = 0$$

$$\frac{1}{m_2}\left[|\vec{T}| - m_2 g\right] + \frac{1}{m_1}\left[|\vec{T}| - \mu_k m_1 g\cos\theta - m_1 g\sin\theta\right] = 0$$

$$|\vec{T}|\left[\frac{1}{m_2} + \frac{1}{m_1}\right] = g + \mu_k g\cos\theta + g\sin\theta$$

$$\boxed{|\vec{T}| = g\left[\mu_k\cos\theta + \sin\theta + 1\right]\frac{m_1 m_2}{m_1 + m_2}}$$

b) To get accel. put in (i) or (iv)

$$(iv) \rightarrow \quad g\left[\mu_k\cos\theta + \sin\theta + 1\right]\frac{m_1 m_2}{m_1 + m_2} - m_2 g = -m_2 a_{1x}$$

$-a_{2y}$

So

$$\boxed{a = -g\left[\mu_k\cos\theta + \sin\theta + 1\right]\frac{m_1}{m_1 + m_2} + g}$$

if you pick block going down the incline then take above answer

let $\mu_k \longrightarrow -\mu_k$

& $a \longrightarrow -a$

(4)

$$F = [\alpha_0 x^2 + \beta_0 x] \text{ Newtons}$$

Each term must have units of Newtons

so $\boxed{[\alpha_0] = \frac{N}{m^2} \text{ or } \frac{kg\ m/s^2}{m^2}}$

$\boxed{[\beta_0] = \frac{N}{m} \text{ or } \frac{kg\ \cancel{m}/s^2}{\cancel{m}}}$

b) $$W_{cable} = \int_{x=0}^{x_{max}} \vec{F} \cdot d\vec{x}$$

$$\vec{F} = -[\alpha_0 x^2 + \beta_0 x]\hat{i}$$

$$d\vec{x} = +dx\,\hat{i}$$

$$W_{cable} = -\int_0^{x_{max}} (\alpha_0 x^2 + \beta_0 x)\,dx$$

$$= -\left[\frac{\alpha_0}{3} x^3 + \frac{\beta_0}{2} x^2\right]_0^{x_{max}}$$

$$= -\left[\frac{\alpha_0}{3} x_{max}^3 + \frac{\beta_0}{2} x_{max}^2\right] = \Delta KE$$

$$= \tfrac{1}{2} m \cancel{v_f^2} - \tfrac{1}{2} m v_i^2$$

0

$\alpha_0 = 0.5\ N/m^2$
$\beta_0 = 100\ N/m$
$x_{max} = 333\ m$
$m = 33700\ kg$

Put in & solve for

$$\boxed{V_i = 26.35\ m}$$