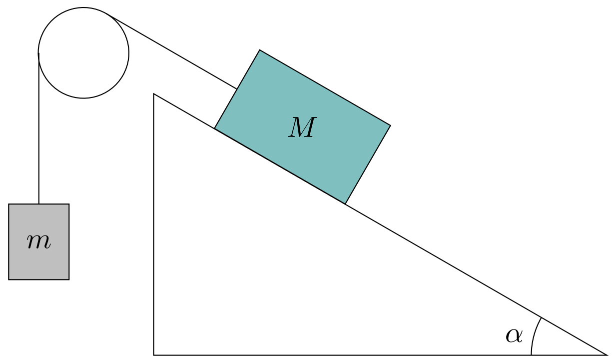
Kinematics Practice (compiled : 2026/05/29 at 17:20; version 1)

Name: ____________________ **Student ID:** ____________________

Problem 1:

A block of mass M is initially still on a frictionless slope set at an angle α. It is attached via a rope hung across a frictionless pulley to a hanging block of mass m. Depending on the angle of the slope and the masses of the blocks, they might stay still, or end up moving in either direction.



(a) For what ratio M/m do the blocks continue to stay still?

○ $\cos(\alpha)$ ○ $\sin(\alpha)$ ○ $\tan(\alpha)$ ○ $1/\cos(\alpha)$ ⊗ $1/\sin(\alpha)$ ○ $1/\tan(\alpha)$

(b) If the string was detached, what would the magnitude of the acceleration of each block be?

a_M : ○ Mg ○ $Mg\sin(\alpha)$ ○ $Mg\cos(\alpha)$ ○ $Mg\tan(\alpha)$ ○ g ⊗ $g\sin(\alpha)$ ○ $g\cos(\alpha)$ ○ $g\tan(\alpha)$

a_m : ○ mg ○ $mg\sin(\alpha)$ ○ $mg\cos(\alpha)$ ○ $mg\tan(\alpha)$ ⊗ g ○ $g\sin(\alpha)$ ○ $g\cos(\alpha)$ ○ $g\tan(\alpha)$

(c) Imagine the blocks masses are balanced as in part (a), such that they stay still. The setup is then put in an elevator that is accelerating upwards at a rate a_{elevator}. What happens to the left block from the perspective of someone standing in the elevator?

○ it moves up ○ it moves down ⊗ it stays still ○ cannot be determined

(d) Suppose the big block is heavy enough that it slides down the slope. After it traverses a distance d, what is its speed? (Answer with a formula that uses the variables given.)

$$\sqrt{2\frac{M\sin(\alpha)-m}{M+m}gd}$$

(e) Imagine the whole setup is rotated an angle α counter-clockwise. Which direction does each block move?

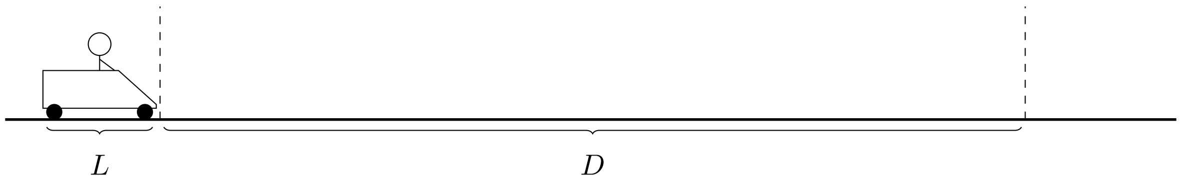
M : ○ up ○ down ⊗ left ○ right ○ up-left ○ up-right ○ down-left ○ down-right

m : ○ up ⊗ down ○ left ○ right ○ up-left ○ up-right ○ down-left ○ down-right

Newton's Laws	**Notable forces**	**Kinematics**
1. $\vec{F}_{\text{net}} = 0 \iff \vec{a} = 0$ **2.** $\vec{F}_{\text{net}} = m\vec{a}$ **3.** $\vec{F}_{\text{by A on B}} = -\vec{F}_{\text{by B on A}}$	$\lvert F_g\rvert = mg$, $g = 10\ \text{m/s}^2$ $\lvert F_{\text{friction}}\rvert = \mu\lvert F_{\text{normal}}\rvert$	$v_x = \frac{dx}{dt}$, $a_x = \frac{dv_x}{dt}$ For a_x constant: $v_{f,x} - v_{i,x} = a_x\Delta t$ $x_f - x_i = v_{i,x}\Delta t + \frac{1}{2}a_x(\Delta t)^2$ $x_f - x_i = \left(\frac{v_{i,x}+v_{f,x}}{2}\right)\Delta t$ $(v_{f,x})^2 - (v_{i,x})^2 = 2a_x(x_f - x_i)$

Problem 2:

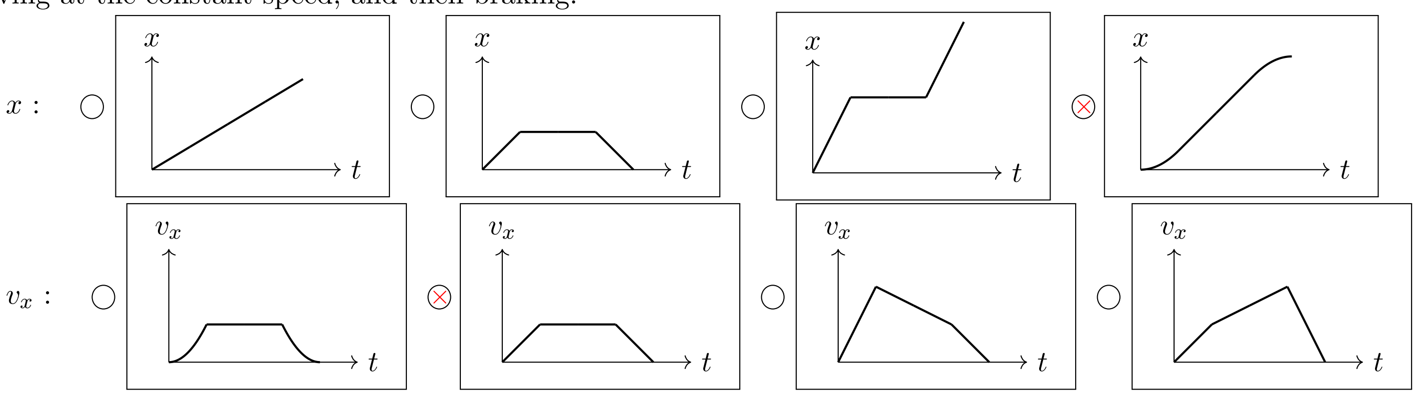
A car of length L participates in a race with a strange rules: the car must be stopped immediately after crossing the finish line a distance D away, and the race is only finished once the whole car crosses the finish line. The car can accelerate with an acceleration $a_{x,+} > 0$ and brake with an acceleration $a_{x,-} < 0$.



(a) If the driver simply accelerated the whole time without stopping at the end, how much time would they take to fully cross the finish line?

⊗ $\sqrt{\frac{2(L+D)}{a_{x,+}}}$ ○ $-\sqrt{\frac{2(L+D)}{a_{x,+}}}$ ○ $\sqrt{\frac{2(L+D)}{a_{x,-}}}$ ○ $-\sqrt{\frac{2(L+D)}{a_{x,-}}}$ ○ $\sqrt{\frac{2D}{a_{x,+}}}$ ○ $-\sqrt{\frac{2D}{a_{x,+}}}$ ○ $\sqrt{\frac{2D}{a_{x,-}}}$ ○ $-\sqrt{\frac{2D}{a_{x,-}}}$
○ $\sqrt{\frac{(L+D)}{a_{x,+}}}$ ○ $-\sqrt{\frac{(L+D)}{a_{x,+}}}$ ○ $\sqrt{\frac{(L+D)}{a_{x,-}}}$ ○ $-\sqrt{\frac{(L+D)}{a_{x,-}}}$ ○ $\sqrt{\frac{D}{a_{x,+}}}$ ○ $-\sqrt{\frac{D}{a_{x,+}}}$ ○ $\sqrt{\frac{D}{a_{x,-}}}$ ○ $-\sqrt{\frac{D}{a_{x,-}}}$

(b) Which of the following graphs for position and velocity depicts the driver accelerating to some top speed, driving at the constant speed, and then braking.



(c) Suppose $a_{x,+} = -a_{x,-}$, so that the driver accelerates and brakes at the same rate. If they never drive at a constant speed, what is their best time for the race? (Answer with a formula that uses the variables given.)
(Hint: draw the graph for v_x and use the area; it will be easier than directly appying the equations...)

$2\sqrt{\frac{L+D}{a_{x,+}}}$

(d) Which of the following objects exert a force directly onto the driver?
☒ Earth ☐ ground ☐ finish line ☒ car seat ☐ tires ☒ seatbelt ☐ sun

For each force you checked, which direction does it point while the car is accelerating? Moving at a constant speed? Braking?

Gravity always down

Seat always up, and to the right when accelerating

Seatbelt to the left when braking

Newton's Laws	**Notable forces**	**Kinematics**
1. $\vec{F}_{\text{net}} = 0 \iff \vec{a} = 0$	$\lvert F_g \rvert = mg$, $g = 10\ \text{m/s}^2$	$v_x = \frac{dx}{dt}$, $a_x = \frac{dv_x}{dt}$
2. $\vec{F}_{\text{net}} = m\vec{a}$	$\lvert F_{\text{friction}} \rvert = \mu \lvert F_{\text{normal}} \rvert$	For a_x constant:
3. $\vec{F}_{\text{by A on B}} = -\vec{F}_{\text{by B on A}}$		$v_{f,x} - v_{i,x} = a_x \Delta t$
		$x_f - x_i = v_{i,x}\Delta t + \frac{1}{2}a_x(\Delta t)^2$
		$x_f - x_i = \left(\frac{v_{i,x}+v_{f,x}}{2}\right)\Delta t$
		$(v_{f,x})^2 - (v_{i,x})^2 = 2a_x(x_f - x_i)$