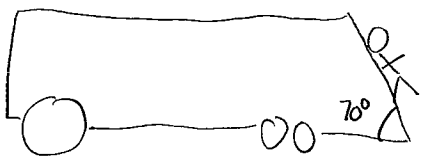
Group Problem

You are working on an action movie being filmed in Oklahoma staring Will Smith. In the next scene of the movie, Will is fighting a villain on the top of the locomotive of a train traveling at 15 m/s. During the fight Will is pushed onto the steel front face of the locomotive that is sloped at an angle of 20° from the vertical, so that the bottom of the front face is more forward than the top. Will's partner, played by Angelina Jolie, needs about 3 seconds before she can grab a rope to save Will. During that time, she needs to keep him from sliding down the front of the train and getting smashed under the wheels of the locomotive. To give herself the necessary time, she steps on the accelerator of the train and accelerates at such a rate so that Will stays in one place on the front of the train. The coefficient of static friction between Will and the steel front of the train is 0.60. The director wants to know how far the train will travel during the time it takes for Angelina to grab the rope. Since the director is your boss, you'd better tell him the correct answer.

Context-Rich Problems: Solutions Outline

FOCUS the PROBLEM

Draw a picture of the situation including ALL the information given in the problem.



$\mu = .60$

$t = 3$ seconds

distance

initial speed

$15\ m/s$

Question(s): What is the problem asking you to find?

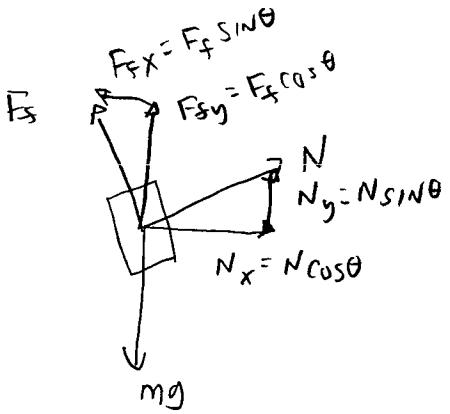
what distance is traveled in 3 seconds at an acceleration which keeps actor on the train.

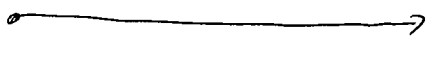
Approach: Outline the approach you will use.

Use Newton's 2nd law to find acceleration and kinematic equations to find distance. Acceleration in vertical direction should be zero.

DESCRIBE the PHYSICS

Draw physics diagram(s) and define ALL quantities uniquely.





$t_1 = 0$ $\quad$ $t_2 = 3$ sec

$X_1 = 0$ $\quad$ $X_2 = ?$

$V_1 = 15\ m/s$ $\quad$ $V_2 = ?$

$a = ?$

Which of your defined quantities is your Target variable(s)? $\boxed{X_2}$

Quantitative Relationships: Write equations you will use to solve this problem.

$F_f = \mu N$ $\quad$ $\sum \vec{F} = ma$ $\quad$ $X_2 - X_1 = V_1(t_2 - t_1) + \frac{1}{2}a(t_2 - t_1)^2$

PLAN the SOLUTION

Construct Specific Equations (Same Number as Unknowns)

Find X_2:

$X_2 - X_1 = V_1(t_2 - t_1) + \frac{1}{2}a(t_2 - t_1)^2$

① $X_2 = V_1 t_2 + \frac{1}{2} a t_2^2$ $\boxed{X_2, a}$

Find a (along x axis):

$\Sigma F_x = ma$

$N\cos\theta - F_f \sin\theta = ma$

② $N\cos\theta - N\mu \sin\theta = ma$ $\boxed{N}$

Find N (use equation along y axis):

$\Sigma F_y = 0$

$F_f \cos\theta + N\sin\theta - mg = 0$

③ $\mu N\cos\theta + N\sin\theta - mg = 0$

$N = \frac{mg}{\mu\cos\theta + \sin\theta}$ (A)

Plug (A) in (2)

$\frac{mg(\cos\theta - \mu\sin\theta)}{\mu\cos\theta + \sin\theta} = ma$ (B)

Plug (B) in (1)

$X_2 = V_1 t_2 + \frac{1}{2}\frac{g(\cos\theta - \mu\sin\theta)}{\mu\cos\theta + \sin\theta} t_2^2$

Check Units

$[L] = \frac{[L]}{[T]}[T] + \frac{L}{[T]^2}[T]^2$ ok

EXECUTE the PLAN

Calculate Target Quantity(ies)

$X_2 = (15\ m/s)(3s) + \frac{1}{2}(9.8\ m/s^2)\left(\frac{\cos 20 - .6\sin 20}{.6\cos 20 + \sin 20}\right)(3s)^2$

$= 81\ m$

EVALUATE the ANSWER

Is Answer Properly Stated?

yes in meters

Is Answer Unreasonable?

Let's find top speed

$X_2 = \frac{(V_1 + V_2)}{2} t_2 \Rightarrow V_2 = \frac{2X_2}{t_2} - V_1 = 39\ m/s$

$= 90$ mph

Very fast, but possible

Is Answer Complete?

yes

(extra space if needed)

Write your Group Number here and the names of the group members who are present.

Group Number:_____

Name:_____

Name:_____

Name:_____

Name:_____