You have been hired as a control engineering consultant for NASCAR, the car racing organization. Your job is to design a control circuit for a robotic camera that will ride on a rail along the straightaway (i.e. the straight part of the racetrack). The camera control system will receive a measurement of the velocity from a selected car. The velocity information will come from the car's own speedometer, via a wireless link. Your job is to make the camera track the car, so that television viewers worldwide can "ride along" next to the driver on the straightaway. You are given the following information:

- The motor that drives the robotic camera along its track is a DC brushed motor with a current amplifier. It produces a force on the camera in response to a voltage input with a calibration coefficient of C_1 N/volt. *i.e controller need to generate control law for force to drive camera.*
- *$F = ma$ $-F_f = M\ddot{x}$*
- The robotic camera has a mass of M.
- There is a tachometer on the robotic camera, which returns the linear velocity of the camera as a voltage with a calibration coefficient of C_2 volts/meter/sec
- The robotic rail system has some static friction, which can be modeled as constant force F_f. Dynamic friction is negligible.
- The wireless link begins working when the car is D_1 meters away from the camera. The robot should be moving at the right speed, right next to the car, after it moves D_2 meters. *so speed of camera = Car speed after D_2 dist.*
- You may assume that the car moves at a constant velocity in the straightaway, and the maximum velocity that it moves at is S.
- You are to design the controller with the lowest gains possible, because NASCAR plans to update your controller next year using a computer-based system. They believe the computer-based system will work better if the controller you design has as low-as-possible gains, because of possible time delays in sampling with the planned computer-based system.

$V = \dfrac{d}{t} \Rightarrow S = \dfrac{D_2}{t}$

$V = \frac{1}{2}at^2$

Design an analog circuit to control the robotic camera. You will get full credit if you:
1) Show your control law, in MKS units.
2) Provide appropriate control gains with units.
3) Show your control law, in units of volts
4) Draw an op-amp circuit that can implement your controller. Label what the inputs and outputs of your circuit should be connected to.
5) Choose appropriate values for the resistors and capacitors in your circuit.

PLEASE ENTER YOUR ANSWERS ON THE ANSWER SHEET
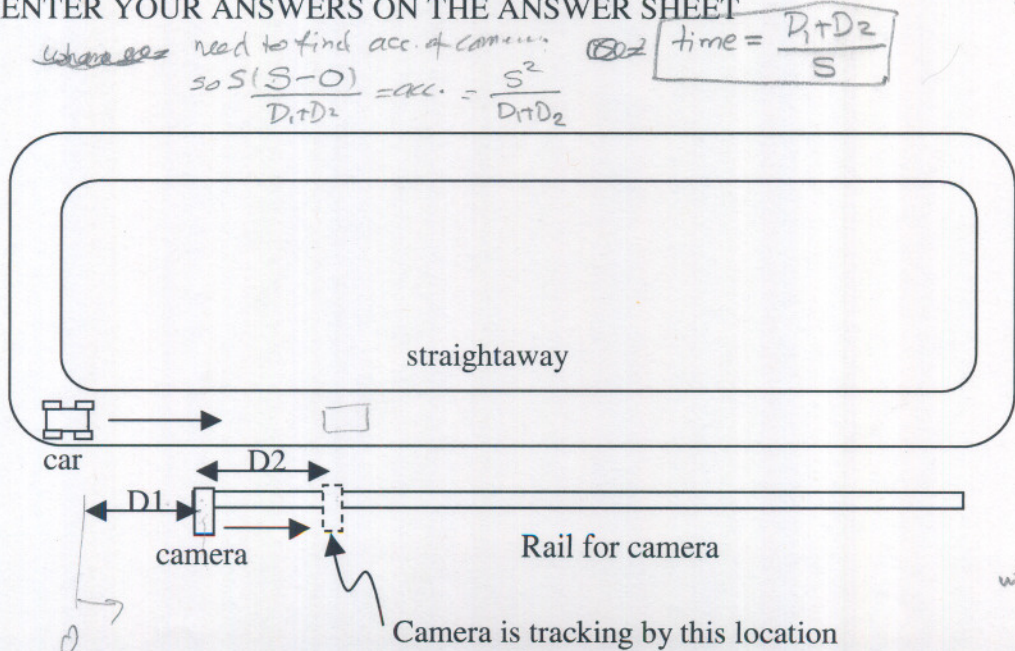
where need to find acc. of camera:
so $\dfrac{S(S-0)}{D_1+D_2} = acc. = \dfrac{S^2}{D_1+D_2}$

$\boxed{time = \dfrac{D_1+D_2}{S}}$

so error is difference in speed.
i.e $\dfrac{S - \dot{x}}{\dot{x}_d - \dot{x}}$
$\dot{x}_d = S$
i.e $\boxed{S - \dot{x}}$
error to minimize
$K_p(\dot{x}_d - \dot{x})$

straightaway

car

D2

D1

camera

Rail for camera

Camera is tracking by this location

$K_p\left((D_2+D_1) - x\right) - K(\dot{x})$
when $x_d = D_1+D_2) = 0$
$x = D_1+D_2$
$-K_d\dot{x}$
so $-K_d S = F_f$