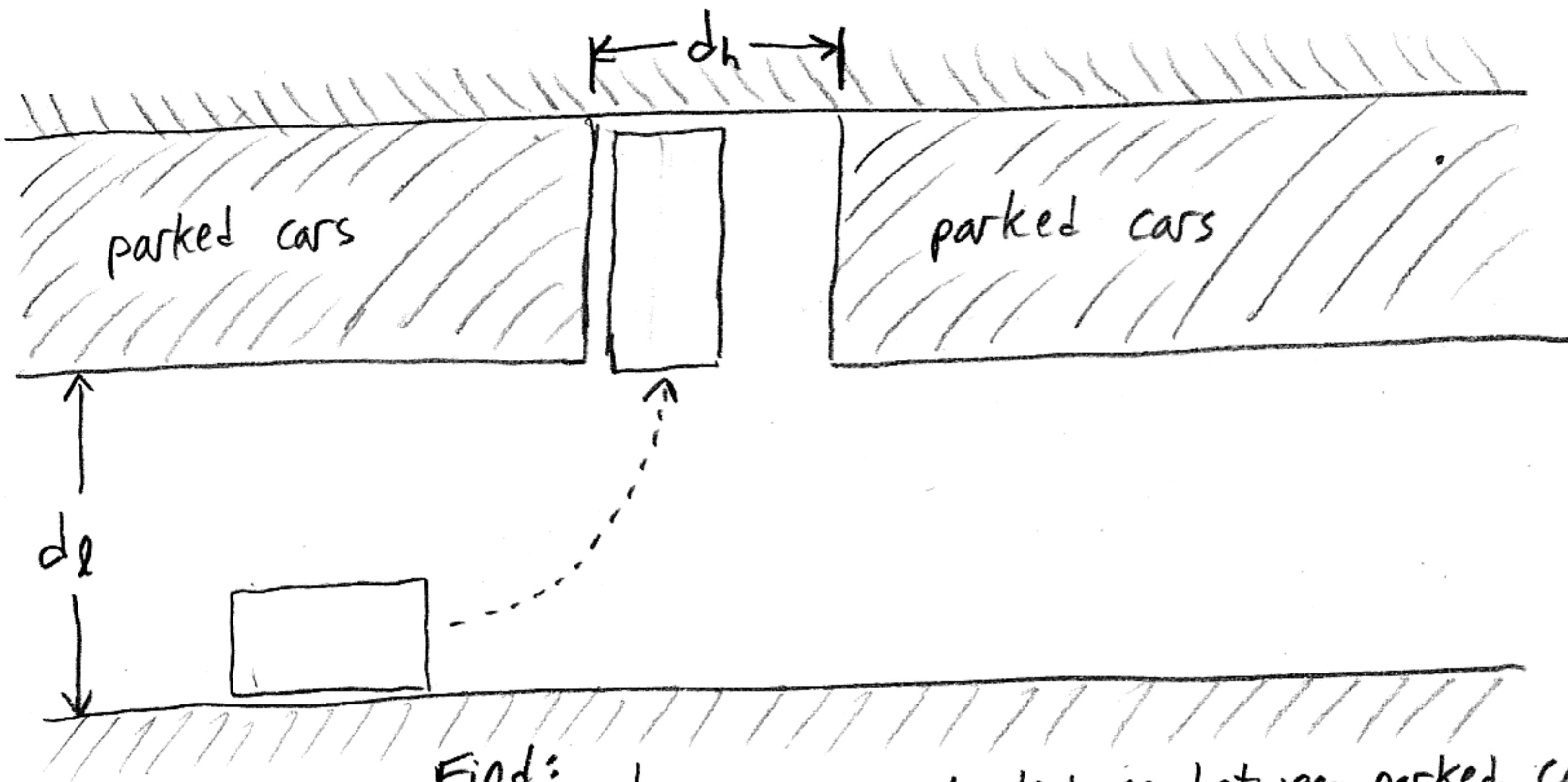


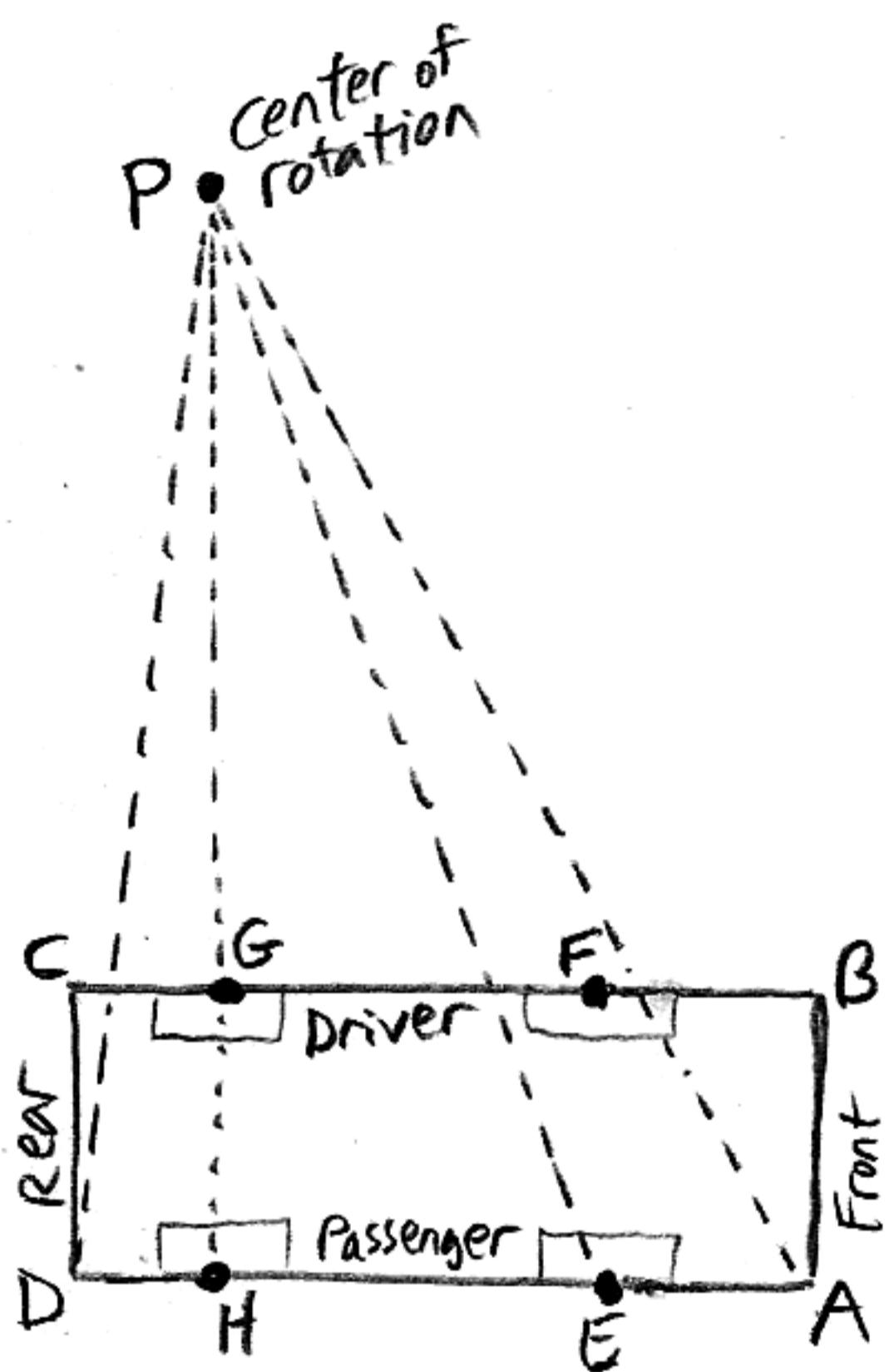
# Perpendicular Parking Optimization

What is the minimal distance  $d_h$  needed between two cars parked perpendicular to the path of travel, given relevant dimensions of the car to be parked and the lateral distance  $d_\ell$  (perpendicular to path of travel) between the parked cars on one side and some other barrier on the other side?



Find:  $d_h$ , minimal distance between parked cars

Given: Car shape modeled as rectangle ABCD with tire centers at E, F, G, and H.



$l = HE = GF$ , wheel base

$k = AE = BF$ , front axle to front bumper

$j = DH = CG$ , rear axle to rear bumper

$w_0 = AB = CD$ , width of car being parked

$r = PE$ , "curb-to-curb" turning radius

$d_\ell = PE$ , lateral distance as shown above

note:  
variables  
chosen to  
be consistent  
with previous  
parallel parking  
study

Dependent variables to be aid in finding solution:

$r_b = PH = \sqrt{r^2 - l^2}$ , radius to outer rear wheel

$n = AH = BG = l + k$ , rear axle to front bumper

$r_j = PD = \sqrt{r_b^2 + j^2}$ , radius to outer rear corner

$r_k = PA = \sqrt{r_b^2 + n^2}$ , radius to outer front corner

$d_p = d_\ell - r_j$ , distance between center of ration and rear edge of parked cars (see following diagrams)

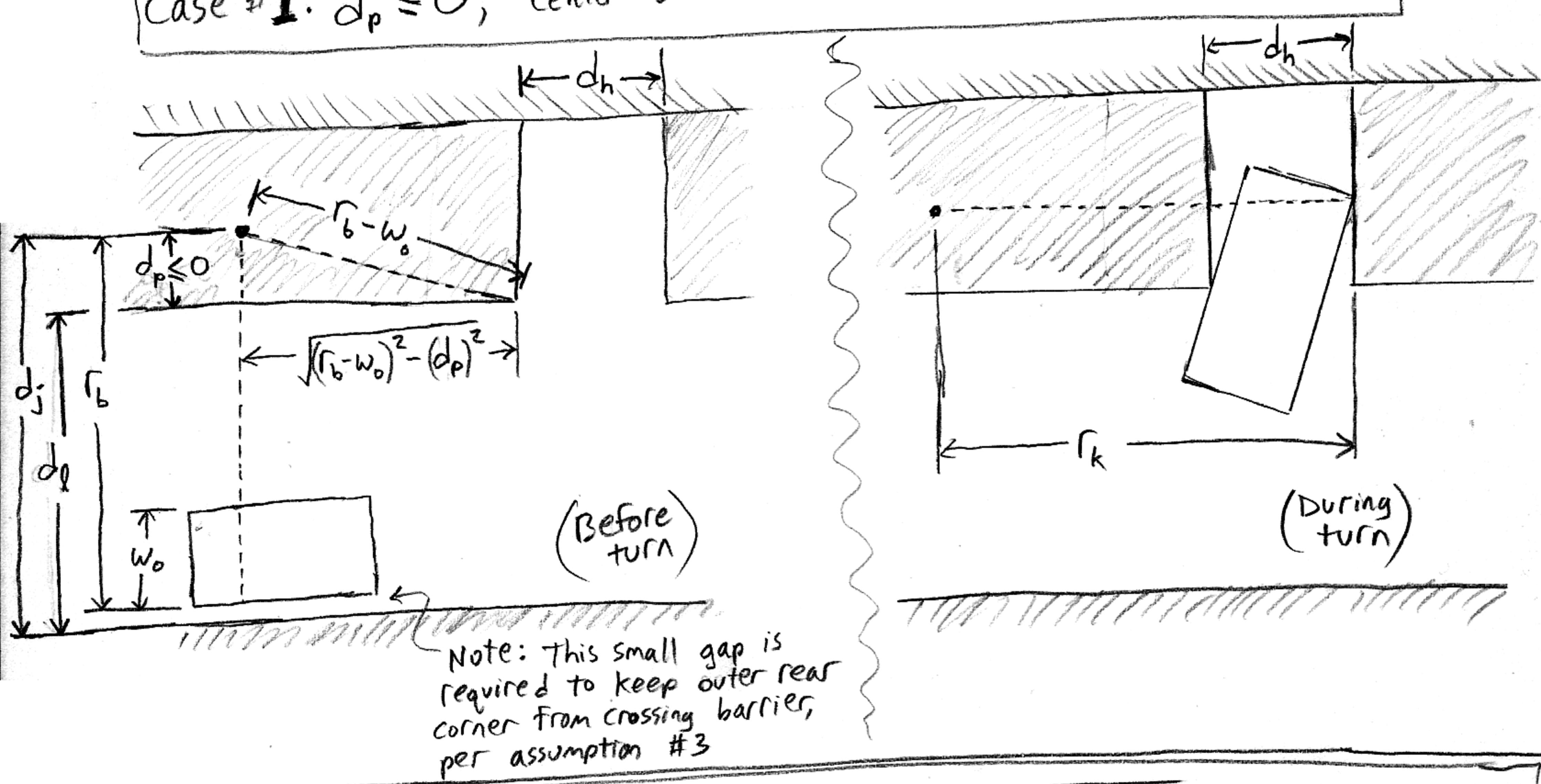
### Assumptions:

1. All relevant assumptions from earlier parallel parking study still hold.
2. Optimized perpendicular parking achieved with tightest possible turning radius throughout entire turn
3. Car to be parked will pull as close to the barrier opposite the parked cars at the start of the turn, but must ensure that rear outer corner (point D) doesn't cross the barrier during turn.
4. Any protrusions of the car to be parked beyond rectangle ABCD (side mirrors, turned front tires, etc.) will be considered negligible for this study.

### Solution:

This solution is developed "piecewise," depending on the value of  $d_p$ .

**Case #1:  $d_p \leq 0$ , center of rotation lies amongst the parked cars**

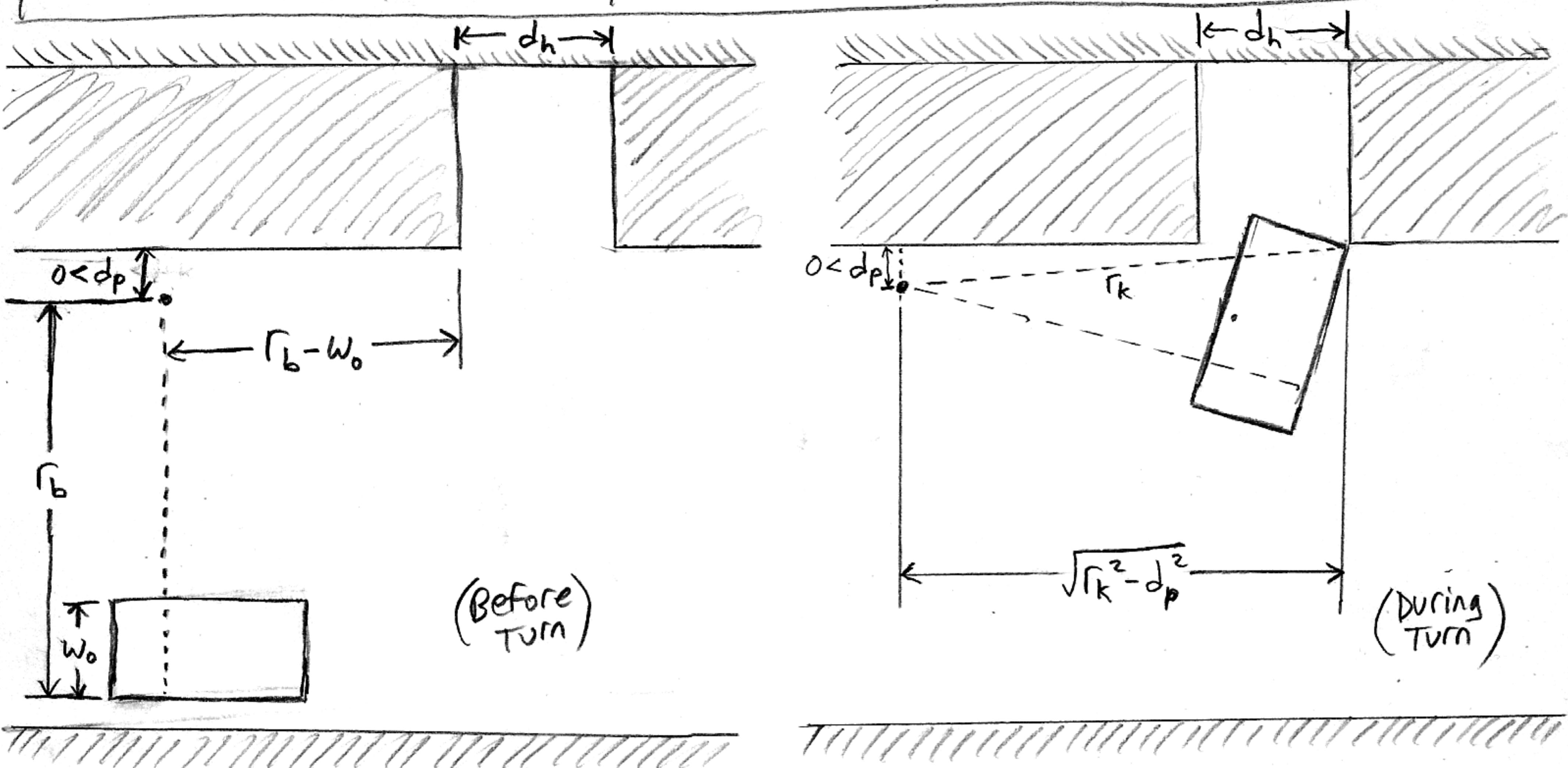


$$\text{For } d_p \leq 0: \quad d_h = r_k - \sqrt{(r_b - w_0)^2 - (d_p)^2}$$

or, in terms of just independent variables:

$$d_h = \sqrt{r^2 - l^2 + (l+k)^2} - \sqrt{(\sqrt{r^2 - l^2} - w_0)^2 - (d_1 - \sqrt{r^2 - l^2 + j^2})^2}$$

**Case #2:**  $0 < d_p < l+k$ , center of rotation lies beyond parked cars, but turn has yet to complete as car enters parking space

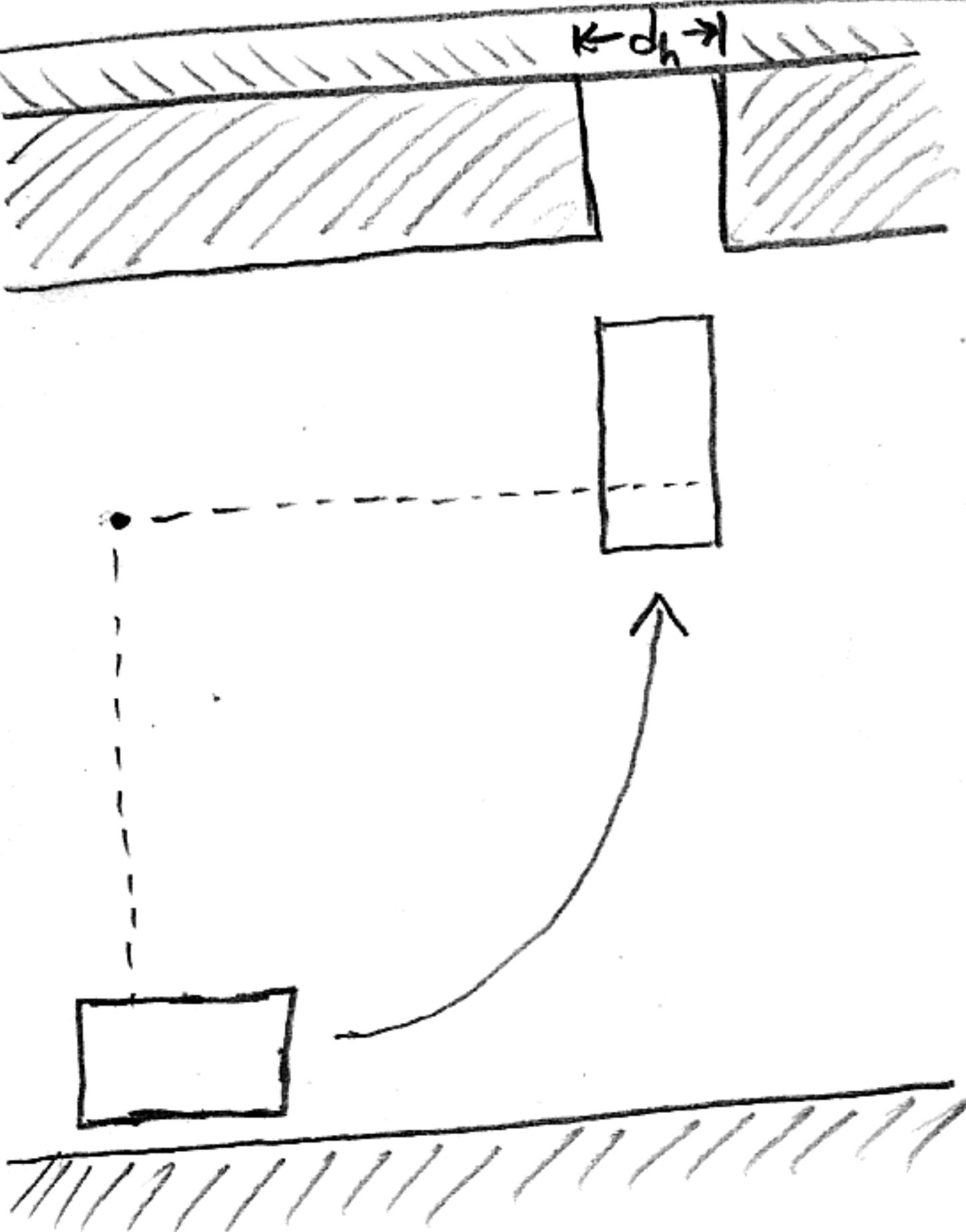


$$\text{For } 0 < d_p < l+k: \quad d_h = \sqrt{(r_k)^2 - (d_p)^2} - (r_b - w_0)$$

or, in terms of just independent variables:

$$d_h = \sqrt{r^2 - l^2 + (l+k)^2} - (d_g - \sqrt{r^2 - l^2 + j^2})^2 - \sqrt{r^2 - l^2} + w_0$$

**Case #3:**  $l+k \leq d_p$ , center of rotation lies far enough beyond parked cars such that turn may be completed prior to entering parking space



For  $l+k \leq d_p$ :

Since car may enter space along a straight path:

$$d_h = w_0$$

Ahh, my favorite!

DAW, p3

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