AST 335 Tractor Center of Gravity and Stability

Objectives:

1). To determine the location of the tractor center of Gravity.
2). To determine angles of impending rear and side tip-over for static conditions.
3). To determine the maximum and minimum speeds and turning radius, at which tip-over occurs when the tractor is operating on a level surface.

Equipment: Suitable Garden Tractor, Scale, Stop Watch and Tape measure.

Procedure:

1. Place rear wheels of tractor (no operator) on scales and record the weight.
2. Repeat with driver.
3. Repeat steps (1) & (2) using front end.
4. Using blocks supplied, raise the front end of the tractor, record the elevated height of the front wheels, and the weight with and without the operator.
5. Measure and record the heights of the front and rear axle centers above a level surface with the operator on board.
6. Record the tread width (Center to Center of tire) of rear wheels and the wheel base (Front-to-rear axle center distance).
7. Determine the tractors maximum ground speed by actual measurement. Time six, 100 ft. runs, with 3 runs in the 'uphill direction' and 3 runs in the 'downhill direction'. Use the average of these runs for the rest of the calculations.
8. Determine the tractors minimum turning radius (at low speeds) by measurement of the tightest turning circle the tractor can achieve. Measure the turning radius for both left and right hand turns. For simplicity you may use the drawbar hitch point as representative of the circumference of the turning radius and the longitudinal plane containing the center of gravity).

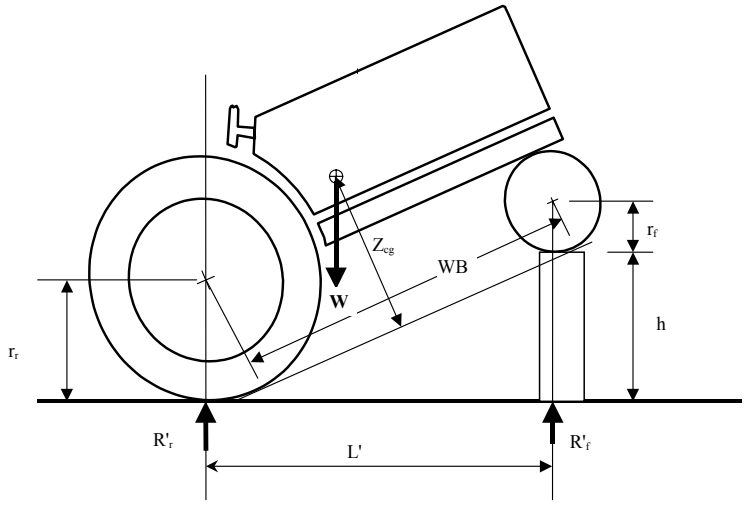
Report:

1. Using the information gathered above determine the horizontal distance (X_{cg}) from the center of rear axle to the center of gravity. (Use Moments on flat surface and measured weights of front and rear).
2. Calculate the vertical distance (Z_{cg}) from the 'ground' to the center of gravity from the equations given below. Make the calculation with and without the operator.

$$Z_{cg} = [(W*X_{cg} - R`_f*WB)/(W*\tan\{\lambda\})] - [(R`_f*\Delta r)/W] + r_r$$

Where:

$\lambda = \lambda_1 + \lambda_2$
$\tan\{\lambda_1\} = h / L`$
$\tan\{\lambda_2\} = \Delta r / WB$
$\Delta r = r_r - r_f$
$L` =$ square root $[(WB)^2 + (\Delta r)^2 - (h)^2]$
WB = Wheelbase
$R`_f$ = Weight on front wheel
W = Total Weight of tractor.



3. Using the location of the center of

gravity calculated above determine the greatest angles to which a stationary tractor can be tilted without tipping over. Calculate the angle for both side and rear tipping with and without the operator.

4. Using the speed and turning radius information, calculate with the operator on board the following

Note: Critical speed for sideways overturn is determined as follows:

$$\text{Critical Speed} = \text{square root} [\ Y_{cg} * g * r / Z_{cg}]$$

where Y_{cg} = Distance from the center of gravity to center of tires
g = acceleration due to gravity
r = turning radius
Z_{cg} = height of the center of gravity

A). Determine the shortest theoretical turning radius that tractor can achieve at maximum measured ground speed without turning over.

B). Determine the maximum theoretical speed that tractor can maintain when turning at the smallest possible turning radius without turning over.

Note: The above calculations assume that the tires will not slip sideways and that the steering angle is ignored.

5. Tabulate your data and results.

Discussion and Results

1. Do your results support your opinions of what angles of tip might be involved? Comment on any differences you think may occur.
2. What percentage of the operators weight goes to the rear wheels. Explain you answer.
3. What effect would a lighter (or heavier) operator have on a). The center of gravity location and b). The angles of tip. Explain your answers.
4. What effect of adding or removing an underslung mover on a). The center of gravity location and b). The angles of tip. Explain your answers.
5. In part four, above you calculated the theoretical minimum turning radius and theoretical maximum speed permissible. Which of the measured parameters were limiting and what are the reasons for this.