Mechanics Corner

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Rocket Homework Problem

1 Introduction

Most engineers find problems involving rockets to be exciting. There is something about a rocket that fires our imagination, whether we think of going to the moon or one of the planets, or simply of shooting down an incoming missile. The subject of this post involves a rocket on a mobile launcher. The rocket is intended to be transported in a horizontal position, but it must be elevated in order to be fired. Both positions are shown in the accompanying figure.

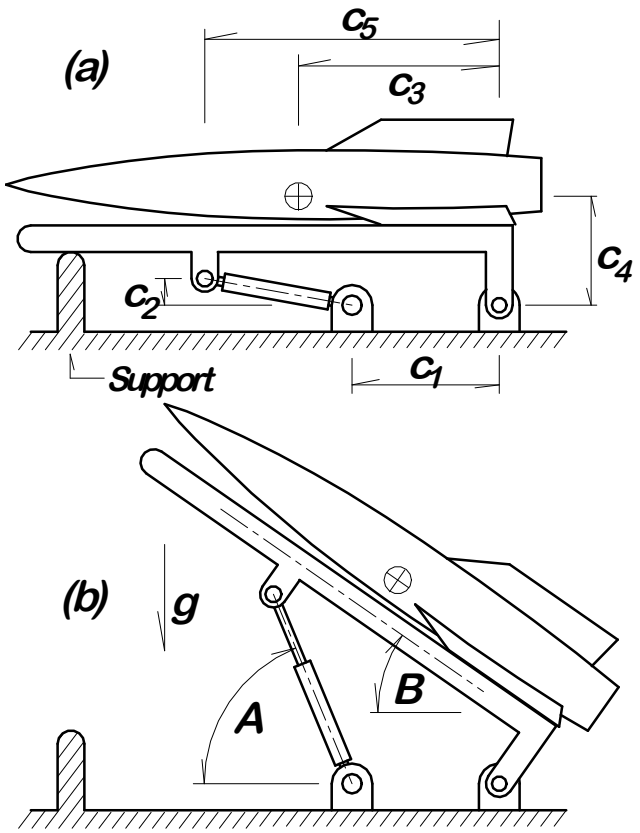

Figure 1: Rocket on the Launcher

In the upper view (a), the rocket is horizontal. The weight of the rocket and the launch platform are initially supported by the fixed support post at the left and the pin connection

at the right. Note that a number of dimensions are given in this view (numerical values given later), so we may consider all of these lengths to be known data. In the lower view (b), the rocket is shown in an elevated position, ready to launch. It should be evident from the figures that the elevation is accomplished by extending the hydraulic cylinder shown. The angles A and B are unknown at the beginning of the problem. Let q denote the (variable) length of the hydraulic cylinder assembly (pin-to-pin).

The known data also includes a value for M, the combined mass of the rocket and support platform, a value of the hydraulic piston diameter, $d_p = 60$ mm, and $g = 9.807$ m/s^2, for the acceleration of gravity.

Known Data Values

$c_1 = 1455$ mm
$c_2 = 257$ mm
$c_3 = 2052$ mm
$c_4 = 955$ mm
$c_5 = 3112$ mm
$M = 1537$ kg

2 Questions

There are a number of engineering questions of interest related to this system. Consider these:

1. What is the value of A when the rocket is in the horizontal (down) position?
2. What is the value of q when the rocket is in the horizontal (down) position?
3. What value of q is required to make the launch angle, B, equal to 45^o?
4. What is the pressure required to lift the lauch assembly off the forward support?
5. What is the pressure required in the hydraulic cylinder to raise the rocket and launcher to $B = 45^o$?
6. Make a plot of launch angle B as a function of the cylinder pressure, P.

3 Closure

I invite all readers to solve this problem. It is not difficult, but I doubt that anyone will solve it without a bit of work (it is that sort of problem). Do not hesitate to utilize everything you know, including some of the information in the early posts on *Mechanics Corner*. In all likelihood, you will find it expedient to use the computer; do not hesitate to write a suitable program to do the numerical work for you (particularly plotting the graph in item 6).

It is not my intention to post a solution for this problem at all. Any reader who thinks (s)he has a solution may write me a message through the *ME Forum* message system, and I will evaluate your answers. (Be sure to write them clearly so that I can read them. My eyes are as old as I am! Also, label each result clearly so that I will know which result is intended to answer which question.)

Let me hasten to assure all reader that this is not a hard problem at all; I have given problems like this for homework for years. This is definitely undergraduate material, so all upper classmen and graduate engineers should zip right through this. There are at least two distinctly different ways to work this problem, so surely you can come up with one of them! Try your luck and see how well you can do! Don't be careless, or you will get burned by the rocket exhaust!!

DrD is a retired Professor of Mechanical Engineering in the USA. Be sure to check back soon at