Your design team works for a company that has been asked to design and build a “brake stick” for the railroad industry.

A brake stick has many uses, but its primary purpose is to actuate the manual hand brake on a railroad car, so that the worker can stay on the ground and not have to climb on the railroad car.

The following photos show a hand brake, and a hand brake being actuated (turned) by a person that has climbed onto the car.

The brake stick has a standard shaped hook on the end that must be incorporated into your design (see Figure 3 for details).

The design goals of the brake stick include:

- minimal weight;
- balanced, ergonomic design;
- extension length 90 inches;
- and it must hold at least 7000 pounds;
- and it must last for at least two years (i.e. you must consider fatigue).
Material Requirements

To evaluate the cost of the structure, use the following values:

- Structural Steel $1/pound
- Aluminum $4/pound

See your instructor for relative values of other materials.
Design Report

Each design group will submit a single final report consisting of four parts that is to be prepared by all team members.

It will consist of a typed cover page containing the names of each team member, and signatures of each team member indicating that they have contributed to the report and have reviewed all calculations.

A summary page will follow the title page that contains (in paragraph form) the dimensions of the structural members (including a sketch of the cross-sections), type of material to be used (including yield strength), the maximum deflection of the structure, the maximum stress in the structure, the anticipated fatigue life, and the cost of the design.

After the summary page should be a scale drawing of the design and of the major structural members that indicates the material type, dimensions of the structure and cross-section, and total structural weight, followed by a detail drawing of connections indicating the placement of any welds or other connections to be used.

The last part of the report will consist of neatly written engineering assumptions, calculations, discussion of appropriate safety factor, and results to support the design.

Hint: Engineers will usually make simplifying assumptions about the geometry and loads of the structure in order for basic calculations to be made. What simple assumptions can you make about the support reactions the geometry, and the loads?
Supplemental Information

Note that improperly applied hand brakes can lead to a “cut” or group of runaway cars. The following information was taken from the Transportation Safety Board of Canada describing the results of a fatal crash from a cut of rails cars, ultimately linked to improperly set or faulty handbrakes.


The Transportation Safety Board of Canada (TSB) investigated this occurrence for the purpose of advancing transportation safety. It is not the function of the Board to assign fault or determine civil or criminal liability.

Main Track Collision
Canadian National
Train 117 and an Uncontrolled Movement of 20 Cars
Mile 122.9, CN Edson Subdivision
Near Edson, Alberta
12 August 1996

Report Number R96C0172

Synopsis

On the evening of Monday, 12 August 1996, all three occupants in the operating cab of the lead locomotive of Canadian National (CN) westward freight train No. 117 were fatally injured when their train, which was travelling at about 54 mph, collided head-on with a cut of 20 runaway cars moving eastward at about 30 mph, some six miles east of Edson, Alberta.

The runaway cars had been left on a track in Edson Yard by a crew who had applied hand brakes to two Government grain covered hopper cars. The crew had received little supervision to ensure that the company's car securement procedures were being correctly applied. The performance of the hand brakes on this type of car was found to be highly variable, and this variability was not commonly known. Also, components from the hand brakes were missing from the two cars on which hand brakes had been set. Although the crew thought the cars had been secured, the resultant brake shoe force on the two cars was insufficient to prevent movement. Thus, the cut of 20 cars slowly moved east and accelerated toward the main track.
5. Hand Brake Performance Reliability

Test data on the brake shoe forces generated by different levels of hand brake wheel torque on different cars indicate wide variations in the brake effectiveness for similar wheel torque.

The fact that, on average, the relationship between torque and brake shoe force is nearly linear, reaching the AAR standard of 10 to 11 per cent of gross vehicle weight at 125 foot-pounds of hand brake wheel torque, should be noted. However, it is clearly possible to have much higher or much lower brake shoe force on one car versus another at the same degree of hand brake wheel application (based on data for the 27 CNWX cars). The hand brake operator has no warning of this variation because the operator only has the feel of the hand brake wheel and the look of the brake shoes on the wheel treads to gauge the amount of retarding force offered by the brakes. Pushing or pulling the secured cars with a locomotive or locomotives would not likely provide useful feedback to evaluate the degree of this variation.

From this graph, it can be seen that the very approximate variation is as follows:

<table>
<thead>
<tr>
<th>Torque (ft.-lb.)</th>
<th>Brake Shoe Force (000 lb.)</th>
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<tbody>
<tr>
<td></td>
<td>Low</td>
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<td>40</td>
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<td>110</td>
<td>13</td>
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<td>120</td>
<td>15</td>
</tr>
</tbody>
</table>

At 60 to 80 foot-pounds of wheel torque (a reasonable expectation for most employees), the possible brake shoe force that would result can vary by a factor of two to three according to these data.