TECHNIKON NATAL

**DEPARTMENT OF MECHANICAL ENGINEERING**

# *ELASTOTRUCK*

## *AN ELEMENTARY DESIGN CHALLENGE*

### BACKGROUND

To succeed in Engineering Design requires a student to be both innovative and analytical without losing sight of the practicalities of implementing a new design.

The analytical skills are taught in subjects such as Mathematics, Theoretical and Applied Mechanics, Strength of Materials, Materials Science, Computer Aided Draughting and so on. Practical skills are taught using *reverse engineering* where existing designs are discussed and criticised and by "hands on" manufacturing of simple components so that an appreciation of the complexities of manufacture may become apparent.

Innovation is another story.

The ability to be innovative and creative is borne out of a personal history of trial and error experiences and the results of these experiences (and/or observations) in games, tasks, duties and responsibilities from early childhood to present, and the relationship of the earlier results (i.e. success or failure!) to the task at hand.
Innovation is taught (?) by using discussions and assignments. Students are led through simple tasks using the basic design "What if..." method whereby variations in actions will lead obviously to logical (in most but not all cases!) variation in results.

Some assignments are designed to be fairly simple tasks, basically exercises, while others are more thought provoking and hopefully enjoyable like the draft which has been enclosed. The idea is to challenge young engineering students innovative and creative design ability while at the same time drawing on the basic mathematical and mechanical knowledge they have learned so far, by presenting them with an *apparently* simple assignment. It was vital that this task acknowledged the disparity in cultural background, finance and facilities available to students and that these factors would neither advantage nor disadvantage any student unduly.

**TASK**

The challenge as seen on the accompanying sheet is to design and build a small, three or four wheeled car propelled exclusively by energy stored in either one or two rubber bands supplied, capable of starting from rest and covering a distance of eight metres down a track marked on a smooth level floor in the minimum elapsed time while carrying a full, sealed 340ml beverage can.

This assignment has been used on two previous occasions and has, by necessity and experience, evolved into its present form.

This discussion topic is aimed at evaluating the concept behind this method of teaching design as well as seeking further refinements, ideas and direction for future development from learned colleagues.

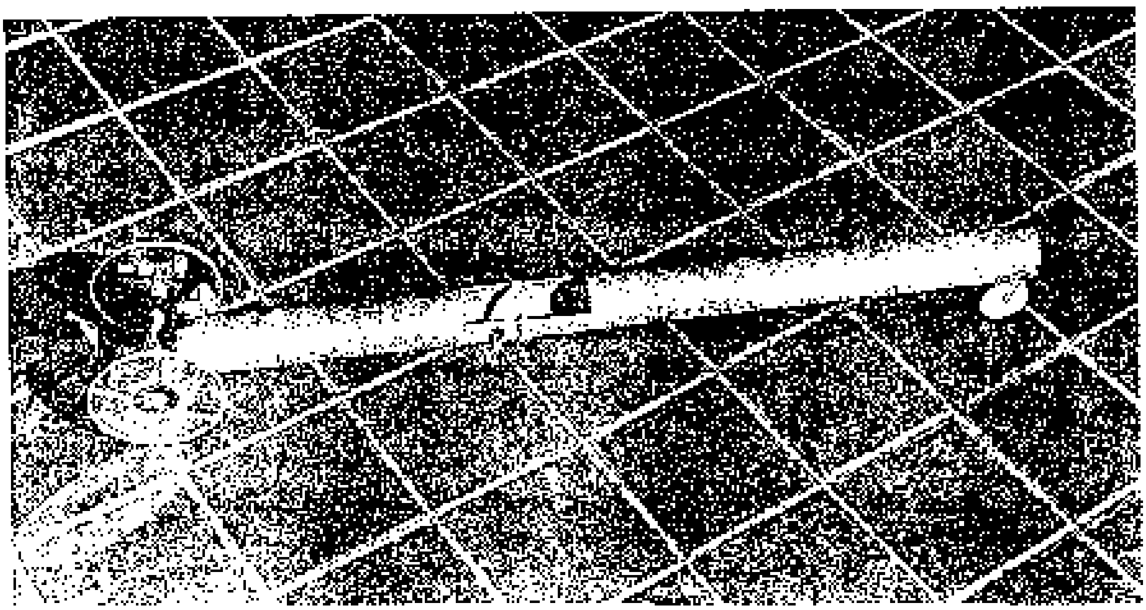
Some points that possibly need to be addressed are :-

- Should this form of assignment form part of a design curriculum?
- If yes, at what levels should they be introduced?
- Should control of the assignment be rigid or relaxed?
- Should assignments be restricted to individual students, partnerships or groups?
- Should intentional "loopholes" be left in the assignment rules?
- The effectiveness of similar assignments at other institutions?
- Suggestions for other low cost assignments?

Peter Allan

Technikon Natal

PS. Winning car from Semester 1 - Elapsed time 2.21 seconds.



# ASSIGNMENT 2 - *ELASTOTRUCK 8000*

Steam power isn't the only way to propel small model cars when wishing to assess the mechanical design aptitude of a student. So .....

Working either individually or with a partner :-

> *Design and build a small, three or four wheeled car* ***propelled exclusively by energy stored in either one or two rubber bands of the type supplied (Size 69 - 6.4mm x 152mm)*** *capable of starting from rest and covering a distance of eight metres down a two metre wide track marked on a smooth level floor in the* ***minimum elapsed time*** *while* ***carrying a full, sealed 340ml beverage can.***

This assignment needs to be undertaken in **THREE** stages.

1) Present a prioritised list of the factors that you think need to be considered when designing your car. Limit your list to **TWELVE ITEMS**. Deadline is 23 April 1998.
2) Designing, building and optimising the car. A neat freehand, annotated design sketch on a standard A3 sketch sheet must be made of your car showing its important features and detailing it's operation. Calculations undertaken should be neatly recorded and also submitted.
3) Present yourself and the car for evaluation (dragging!) on the agreed date.

## The quality or effectiveness of the design will be assessed by :-

a) evaluating the list of prioritised factors that you as designers would consider (10%)
b) measuring the **elapsed time** needed to cover the **EIGHT metre** distance. (60%)
   **NOTE** :Only the **LOWEST ELAPSED TIME** will score the full 60%.
   Cars that take **TWICE AS LONG** will only score ***half these marks***,
   and a pro rata mark will apply for all other times.
   Cars that fail to cover the distance will not score more than 10% for this mark
c) examining the design for any innovative and effective ideas. (30%)
   This will be done by visually inspecting both the car **and** the freehand sketch(s) which must be submitted with the car. Any calculations submitted will also be evaluated.

### The rules are :

1) The car should essentially be built from scrap or offcuts and have little real monetary value.
2) **No machine tools** may be used in the construction of the car - **only hand tools**.
3) No ready made commercial components may be used in their intended roles i.e. toy wheels may not be used as wheels - tin lids or bottle tops or something similar should be adapted.
4) **No toothed gearing** is permitted. No spiked wheels may be used to improve traction.
5) No additional forms of stored energy may be utilised to ***directly power the car*** but components like rubber bands, springs etc. may be used for other purposes e.g. to hold components on the car, suspension etc. if required
6) The car may not be pushed at the start, only released.
7) **A catapult type** stored energy launch from a fixed stationary object is **not permitted**
8) The rubber bands supplied, may be modified in any way except the addition of extra material.
9) Marks will be awarded based on the lowest elapsed time over the eight metre distance, irrespective of the number of students in the team. (Remember maximum is two!)
10) Joining of components may be done using any small fasteners (screws, nuts, nails etc) or by using any type of glue (solvent or epoxy). Any form of welding or brazing is ***not*** permitted.

**THE CARS WILL BE TESTED FROM 12:30 to 15:30 ON 20 MAY 1998 IN ROOM S7 503 AND THEN ASSESSED THEREAFTER.**

P.D. Allen
98/04/14

# ELASTOTRUCK - PRIORITISED DESIGN CRITERIA

1. Resources availability. (Materials, tools, skills and time!)
2. Beverage can mass and overall truck mass.
3. Elastic band force / extension characteristics.
4. Chassis stiffness to tolerate elastic band loads. (Axial and torsional??)
5. Overall length to accommodate extended elastic band.
6. Elastic band force / wheel tractive force ratio.
7. Mass distribution. (Front/rear)
8. Wheel / floor co-efficient of friction.
9. Elastic band / cord release.
10. Steering stability
11. Rear axle bearing effectiveness. (Load capability and friction)
12. Rear axle stiffness.

**NOTE** : The list given above is certainly not the only list.
It is probably not even the best list, but it is supplied to show the sort of criteria that need to be considered for this assignment.
If a cutoff of twelve items was not a constraint, the list could easily extend to several pages!

pda

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# ELASTOTRUCK 3000

Some items within the areas that need to be considered are :-

| RESOURCES | ENERGY UTILIZATION | LOADS ON COMPONENTS | STRENGTH OF COMPONENTS | DYNAMICS | MANUFACTURE |
|---|---|---|---|---|---|
| Materials<br>Tools<br>Working Space<br>Experience<br>"Contact" network<br>Cost factor | Mech. Properties of rubber bands<br>Twist or stretch<br>Load/ext. Diagram<br>Use in parallel or series<br>Rubber band life | Can mass<br>Elastic loads<br>Reaction loads<br>Impact loads (If crashed!) | Frame/Chassis<br>Axle<br>Axle supports (Bearings)<br>Tension member (string/cord) | Basic vehicle Dynamics : f,m.a<br>Drive ratios<br>Differential ratios of pulleys/wheels<br>Variable ratio drive (Cone pulley)<br>Wheel/Track coeff. of friction<br>Rolling resistance<br>Bearing friction<br>Mass distribution<br>Steering stability | Primary/Secondary<br>Cutting drilling and joining limitations. (Tools and rules!)<br>Assembly<br>Disassembly<br>Reassembly |