

# WEIR-WARMAN AND ENGINEERS AUSTRALIA DESIGN & BUILD COMPETITION - 2004

## *Project “PEP” – Potential Energy Propulsion*

There is growing concern about energy usage on the planet Gondwana. Much discussion has engaged the Gondwanan population in regard to their future and the sustainment of transportation systems in particular has become a major issue. A proposal with significant political support has been a “green” one using the energy of the trade winds – a prevalent energy source across much of the Gondwanan landscape.

In the “Quixote quadrant” of the planet, where windmills abound, a trial is proposed. However, while the concept of a windmill being used to store energy by raising large masses, the challenge is to design a device and associated infrastructure that utilises the energy released when the masses are allowed to fall. Conceivably, an efficient transport network with windmill nodes appropriately distributed could be developed.

In the “ACME Pinnacle Laboratory”, the Gondwanan Energy Commission is struggling to arrive at a design for potential energy propulsion of transport devices. Fortunately, teams of engineering students from Earth are about to visit Gondwana as part of their work experience programmes. On previous visits engineering students have rendered invaluable assistance, and the Gondwanans again seek help from these budding engineers.

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### *Objective*

The objective is to design, build and prove a prototype device in a laboratory environment that maximises transportation efficiency. Can your team invent the transportation breakthrough for Gondwana and perhaps the Galaxy, using **Potential Energy Propulsion**?

See below for:

- Competition Rules
  - Frequently Asked Questions
  - Further Competition Details
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## **Competition Rules**

*Original Released: 25/02/2004*

### Revision 1: 10/03/2004

*Preamble edited to replace “vehicle” with “device”*

*Rule 20 – Edited*

*Rule 35 – Sore formula modified*

*Rule 37 – Edited*

*Figure 1 Caption note deleted*

### Revision 2: 19/03/2004

*Rule 12 – Edited to address VCG changes*

*Rule 24 – Edited re 400mm cube sitting on road*

*Rule 29 – Edited re device sitting on road*

### Revision 3: 07/04/2004

*Rule 11 – Edited to address “maximum distance” mass falls through*

*Rule 18 – Edited to address distance mass falls through and allowable penetration of intermediate element volume*

*Rule 21 – Type of rice to be used defined*

### Revision 4: 25/05/2004

*Rule 10 – Edited to clarify that the start rest is a permanent feature of the track*

*Rule 14 – Edited to address a revision of suggested method of rigging gantry*

## **ELIGIBILITY**

1. Teams of up to four second-year mechanical-engineering students in Australian or New Zealand universities may enter the competition. Teams of three or four are recommended.

## **SAFETY**

2. Safety is of paramount importance when participating in this competition. All engineers should know that injury and damage to equipment and the environment occurs when the control of energy in a system is lost.

3. Safety glasses or full face masks should be worn by all students working on devices at all times, during construction, during testing, and during competitions.

*(Please be aware that in 2003 during a campus competition, a student was lucky to escape serious eye injury when a device went off unexpectedly.)*

## **MATERIALS AND MANUFACTURE**

4. Students should manufacture their prototype device themselves using commonly available materials, components and methods.

5. Devices that are deemed by the judges to be hazardous will not be permitted to run. In particular, devices which damage the competition site are prohibited.

6. The energy used to drive the device must be solely derived from a falling mass described in Rule (11) below.

## **TRACK**

7. The competition site modelling a “road” shall consist of three sheets of Medium Density Fibreboard (MDF) of nominal dimensions 2400 x 1200 x 19 mm joined together, end to end (see Figure 1).

8. All surfaces of the MDF sheets will be brush coated with one coat of Wattyl Estapol Speed Clear followed by two coats of Wattyl Instant Estapol Matt.

9. The profile of the road, as shown in Figure 1, models a gently rising valley floor and hill with three distinct and increasing gradients (approximately 5%, 10% and 20% assuming standard 2400 length sheet). The highest point of the track is to be set at a height of 0.81 m above the “start line”. The intermediate changes in gradient occur at heights of 0.09 and 0.33 m above the start. Transversely, the road is horizontal (having no camber).

10. A “start rest” comprising a 45x45 mm timber batten or similar will define the transverse “start line” with its forward leading face 600 mm from the lowest (free) end of the first sheet. **The batten is to be secured in place (e.g., with screws) forming a permanent feature of the competition site.**

11. A gantry arrangement adjacent to the start will allow a mass of 1, 1.5, 2, 2.5, 3, 3.5 or 4 kilograms to be dropped vertically through a **maximum** distance of 1 metre. A trap door type mechanism as shown in the concept drawing (Figure 1) may be used, as may a clamp or brake mechanism on the line, to hold and release the mass.

12. The energy from the falling mass must be converted and is the only energy which can be used to drive the device. **If the device was to be placed on a horizontal road surface in its pre energy loading state and in its end of run state, there shall be no reduction in the device's vertical centre of gravity.**

13. The falling mass will be linked through an inelastic and near frictionless system to a “size 3 brass barrel swivel and interlock” (see Figure 2) supported by the gantry. The interlock will be presented at the start of set up at an approximate location longitudinally 200 mm behind the “start rest”, on the road centerline and 200 mm perpendicularly above the road. The suspension point for the interlock shall be nominally 1.5 metres above the road.

14. While dictated by local constraints and the availability of components, ~~to minimize cost, it is suggested that the inelastic system linking the mass and interlock comprise a 16 kilograms or heavier monofilament fishing line, run through the free eye of two “size 3 brass barrel swivels” pinned to the gantry. Alternatively, utilize a pulley system could be utilized.~~ To facilitate fine length adjustment, a vertical screw thread height adjustment could be included in the arrangement of the ~~fixed swivel(s) or pulley(s).~~ **(NOTE: The use of the fishing line running through the swivels proved to have two major problems, elastic behaviour of the fishing line and unacceptable friction in the eyes of the swivel.)**

15. The team may use any means to connect their device or “intermediate element” to the interlock.

16. The intermediate element is not considered part of the “device”, can be of any mass up to approximately 15 kilograms and shall be air transportable in standard checked baggage. When assembled for the competition and for the duration of the run, the intermediate element must be contained within the volume of a right rectangular prism with its top 1 m from the road surface, its bottom the road surface, its ends 1.0 m ahead and 0.6 m behind the starting line and its sides the vertical projection of the road edge.

17. The intermediate element shall not add additional energy to the system in any way.

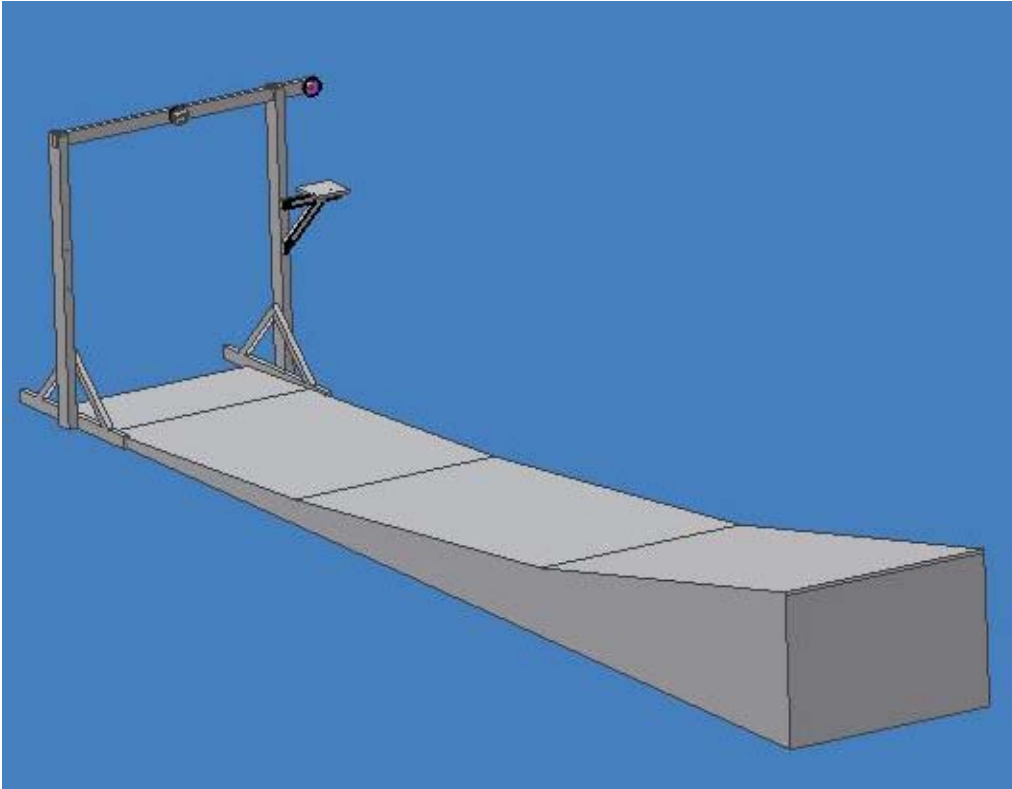
18. After the mass has fallen through a **maximum of** one metre, the interlock will have travelled upwards, linearly towards the running fixture (eye of swivel or pulley) ~~one metre a~~ **distance equal to that through which the weight has fallen.** This movement is not necessarily constrained to be vertical. **It is noted that the final position of the interlock and a segment of the connector attached by the Team to the interlock may be outside the volume defined for**

**the intermediate element (see Rule 16) at the end of the energy insertion phase. This is the only acceptable penetration of the intermediate element volume defined in Rule 16.**

## **PROCEDURE**

19. The “net mass” of the device, will be measured in kilograms (with an accuracy of 10 grams). The device shall not exceed a net mass of 4 kilograms.
20. The Team shall nominate the “gross mass” of their ~~vehicle~~ device as 1, 1.5, 2, 2.5, 3, 3.5 or 4 kilograms.
21. A “payload” (gross mass – net mass) in the form of **dry white calrose medium grain** rice will be measured into a standard 10 litre plastic bucket by an official.
22. A mass equal to the nominated “gross mass” will be installed by the officials on the gantry as per Rule (11).
23. When the track is clear, the Team will be handed the bucket containing the rice and allowed a maximum of two minutes to set up their device and intermediate element on the competition site. During these two minutes, the link shall be established between the device or intermediate element and the interlock, the payload shall be loaded from the bucket into the device and the empty bucket shall be returned to the judges.
24. Prior to running and after set up, the device must be wholly contained within a 400 mm cubic envelope which has two faces parallel with the road surface **and one of these faces in the plane of the road surface**, be stationary and be positioned during set up such that its “trailing edge” is in or behind the plane of the “start rest” which is perpendicular to the road surface (see Figure 1). This may be physically checked by an official. Similarly, the intermediate element if used must be within the rectangular prism defined in Rule 16. This may also be physically checked by an official.
25. During the measuring and set-up processes the Team shall make clear to the judges what components constitute the device and what components constitute the intermediate element.
26. The team will nominate a one-step or two-step starting sequence.
27. In the case of a one-step starting sequence, the run timing shall start from the instant the falling mass is released. The mass shall only be released with the approval of the “official starter”.
28. In the case of a two-step starting sequence, the falling mass will be released during the two minute set up time. The team may continue setting up, for example to decouple the interlock from their device or intermediate element, up to the maximum set up time without adding energy to the system. After the mass has been dropped, the device shall not be moved by a team member. The device will be started when directed by the “official starter” using a single action that does not impart motion to the device.
29. In either starting sequence, team members shall not be touching the device or intermediate element during the time that the mass is falling. **Before “energy insertion”, the device shall be sitting on the road surface in a similar configuration to its intended final position at the end of the run (see Rule 12).**
30. On instruction from the starter, the run will commence and the run must be completed within 120 seconds.





**FIGURE 1 - PROJECT “PEP” COMPETITION TRACK CONCEPT**

(Please note this drawing is to be updated to reflect a gradient in the first panel)



**FIGURE 2 - SIZE 3 BRASS BARREL SWIVEL AND INTERLOCK**  
(Sample brand “Seahorse” – approximately full size)

## Frequently Asked Questions

(Last Updated: 25/05/2004)

### 1. What is the price and availability of the suggested rig components?

The swivel is a standard item available at any good fishing tackle supplier including outlets such as Kmart, Big W, etc. I paid A\$5.50 for 10 swivels with interlocks, A\$2.65 for 10 swivels and \$3.95 for 15 m of 16kg line.

### 2. In Figure 1 it looks as though there is a short horizontal section right near the gantry for the falling masses.

What you are seeing as a “fourth surface” does not exist. The line at the gantry is representative of the start rest and the distance from the start rest to the first change in gradient of the track is 1800 mm. Please refer to rules 9 and 10.

### 3. Rule 34 states that “All rice shall be returned to the organisers at the completion of each run”. It does not seem to state the rice has to remain on the vehicle once placed there. Please clarify.

The rice is the payload / ballast of the device and should remain with the device. It is considered part of the device once it has been added. See rule 20 and consider rule 36. If rice is left behind, the variable “distance” will be defined by the measurement made to the closest grain of rice.

### 4. An intermediate element must be contained within a 1 m height above the “road” (see Rule 16) during a run – the intermediate element might contain a string which will be attached to the interlock and after a mass is dropped through 1 m distance the string can be pulled above 1 m height. Is this acceptable?

The intermediate element(s) cannot go outside the stated volume at any time with the exception of the “string” attached to the interlock.

### 5. Is it the rice that falls one meter?

No, it will probably be a collection of steel and/or lead weights. The rice is a payload on your device but is considered to be part of your device. You can decide how to carry the rice but you can not damage it.

### 6. Can my equipment interact with the mass or string?

No, you only get to touch / link to the interlock on the end of the line as shown in Figure 2.

### 7. Does the device have to stay in contact with the MDF at all times?

The rules do not say that your device must remain in contact with the MDF at all times but it can only come in contact with those items listed in Rule 32. The rules describe the pre-energy insertion condition and the final stationary condition of the device. Between those states your device may move in any way you wish while abiding by Rule 32.

### 8. Once the falling weight reaches its lowest point, the swivel and interlock and connector will be outside the intermediate element volume defined in Rule 16. What if this connector is cut and leaves a remnant on the interlock during the run?

Firstly, see the addition to rule 18 as part of Revision 3. Nothing in principle should be left outside the volume but a connector hanging from the interlock that was not part of the device is acceptable.

**9. In a two step starting sequence, is it permissible, after the weight has fallen, to reposition the intermediate element within the permitted envelope?**

No. The intention is that nothing should be moved in a gross way after energy input. The allowing of set-up continuing is primarily to allow such things as lines to be uncoupled / rearranged and fine adjustments to be made. However, Rule 28 clearly says “After the mass has been dropped, the device shall not be moved by a team member.” What is important is that no other energy is seen to be inserted, even if it is not used.

**10. During setup and before “energy insertion”, can the mass be lowered to take up any slack in the system? Rule 11 seems to allow the mass to fall a distance smaller than one metre, in the sense that it STARTS the energy insertion phase less than 1m above its stop.**

No. Before energy insertion, if you want to take up any slack in your device / intermediate element, this must be done without lowering the mass. The energy insertion is to occur in one step and the only interaction with the vertical position of the mass during the set-up evolution is to be when it is released via the trapdoor swinging away or the brake being removed. The mass when released should have the ability to fall a full 1 metre. Whether it does or not is a function of the device / intermediate element’s ability to store all available energy.

**11. Please provide some details of a constructed track and gantry.**

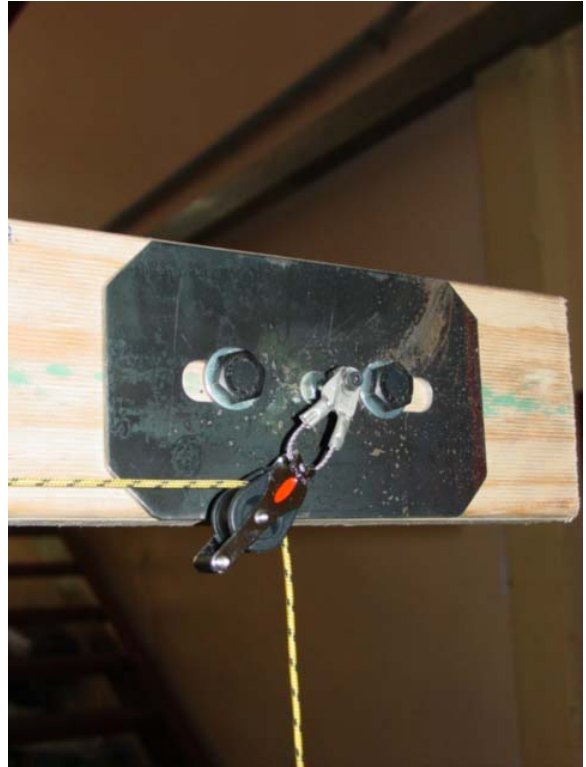
The following photos are of the track fabricated for the UNSW@ADFA campus competition. The gantry arrangement utilises some ball bearing 20 mm single pulley blocks (Ronstan brand) sourced from a local ship-chandlery and 2 mm “spectra” cord also sourced from the chandlery.



**FIGURE FAQ 11a - UNSW@ADFA Track**



**FIGURE FAQ 11b - UNSW@ADFA**  
Trapdoor and Gantry Arrangement



**FIGURE FAQ 11c - UNSW@ADFA**  
Ronstan Pulley Blocks

**12. Can the intermediate element be secured / clamped to the start rest?**

No. While not addressed explicitly, you should use the intermediate element's self weight to react the forces applied. You can of course use the start rest as well but you cannot "attach" to it. Rule 5 also speaks to not damaging the track.

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## **Further Competition Details**

*(Last Updated: 26/07/2004)*

### **NATIONAL FINAL**

The Weir-Warman National Final had been tentatively set down for Friday 24 - Saturday 25 September 2004 at Sydney's Powerhouse Museum. These dates will be confirmed later in the year.

#### 25 May 04

Unfortunately, due to the Powerhouse Museum's 125 year birthday celebrations which clash with the dates set for the Final, we will not be able to use the facilities at the PHM. The NCED is currently considering alternate venues. As a result there is a possibility that the National Final may not be held in Sydney. A slight change to the dates of the National Final may also be necessary.

#### 26 July 04

The National Final will be held in Sydney 24-26 September at the University of Technology, Sydney (UTS) with students returning home on Monday 27th.

The format will have students gathering for an initial briefing on Friday morning and a tour of Weir Warman Ltd on Friday afternoon. Practice time and briefings will be held on Saturday and the actual running of the final and the National Finals dinner will be on the Sunday.

A team registration form is available on the competition web site. Teams will be forwarded more detailed information as arrangements are made and confirmed. Travel arrangements are coordinated by Nina Lenz of Engineers Australia.

### **SPIRIT OF THE COMPETITION**

The rules look rigid because we have tried to be very clear on the important points. Engineering reality is rarely so specific. It is essential to Work with your campus organiser from an early stage, and for the campus organiser to verify decisions with the National Organiser so that everyone has the same understanding of the meaning of the rules. If you think you see a loophole, clear it with your campus organiser before you rely on it in competition. Even if you get away with it at local level, you might be in for a shock at the national level where the interpretation might be different. Provision will be made for confidentiality, so your idea will not be passed on to other students.

The competition site will be made with reasonable care but because it is a real engineering object it may well be "wrong" in various small ways. For example the planes of the slope might not be exactly at the specified angle, or might have a slight transverse slope. Your team is expected to consider these possibilities in your design, and develop a device that can function even if the competition site has slight imperfections. In other words, you are not allowed to blame failure of your device on some minor imperfection with the competition site.