UPVAN MITTAL'S
MONTHLY
PHYSICS CHALLENGE

- **All the problems posted here are strictly within IIT-JEE syllabus.☺**
- **The problems are not meant to be exceptionally difficult.☺ They are only meant to test the clarity of your basic physics concepts and your capability to apply them to various problems. (This is exactly where IIT-JEE tests you! ☹)**
- **It is expected that you try these problems on your own ☹ but you may discuss them with your friends/seniors/teachers if you are really stuck ☺.**
- **ALL the problems (alongwith the solutions) being posted here have been taken from my articles in the National level science magazines published over past 5 years. Their 'correctness' has been thoroughly cross checked by the expert panels of these magzines as well as numerous teachers/students throughout the country ☺.**
- **For Detailed solutions contact Insight reception ☺.**
- **And finally, there are no grand prizes for submitting the correct solutions.☹ At best, you may recieve a choclate from me if you come up with a particularly ingenious solution.☺**

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CHALLENGE PROBLEM 1

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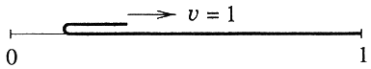
Centre of Mass

A long, thin, pliable carpet is laid on the floor. One end of the carpet is bent back and then pulled backwards with constant unit velocity, just above the part of the carpet which is still at rest on the floor.



Find the speed of the centre of mass of the moving part. What is the minimum force needed to pull the moving part, if the carpet has unit length and unit mass?

Note: The answer is NOT 1units.

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CHALLENGE PROBLEM 2

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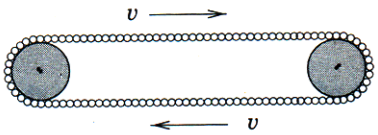
Circular Motion

A flexible chain of uniform mass distribution is wrapped tightly round two cylinders so that its form is that of a stadium running-track, i.e. it consists of two semicircles joined by two straight sections. The cylinders are made to rotate cause the chain to move with speed υ.



For some reason, the chain suddenly slips off the cylinders and falls vertically. How does the shape of the chain vary during the fall ?

According to swagat, it takes a circular shape because of the centrifugal force. Pankaj accepts this point, but then considers that the initially 'elliptical' chain will be deformed beyond the circular shape by this effect and become a vertical ellipse with its new major axis at right angles to the original one. He expects that this process will repeat itself and that the chain shape will cycle between the two 'ellipses'. Chirag guesses that the chain retains its original shape, but the cannot give any reasons for his guess. Who is right – or are they perhaps all wrong?

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CHALLENGE PROBLEM 3

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Centre of Mass

Two 20-g flatworms climb over a very thin wall, 10 cm high. One of the worms is 20 cm long, the other is wider and only 10 cm long. Which of them has done more work against gravity when half of it is over the top of the wall ? What is the ratio of the amounts of work done by the two worms?

Note: Be careful! The most obvious answer is not the right answer!

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CHALLENGE PROBLEM 4

Circular Motion

A moving cart is shown on a cinema screen. The radius of the front wheels of the cart r_1 metre and that of the rear ones $r_2=1.5r_1$. The front wheels have N_1 symmetrically placed spokes. The film in the cinema camera moves with a speed of f = 24 frames per second.

(a) **Assuming that the wheels of the cart do not slip, find the minimum speed with which the cart should move for its front wheels to seem stationary on the screen. What minimum number of spokes N_2 should the rear wheels have for them also to seem stationary? Assume that N_1 is even for this part of the question.**

(b) **At what speeds of the cart moving from the left to the right will it seem to the audience that the spokes of the wheels rotates counterclockwise? Take the number of spokes to be 6 in each wheel for this part of the problem.**

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CHALLENGE PROBLEM 5

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Circular Motion

The minute hand of a church clock is twice as long as the hour hand. At what time after midnight does the end of the minute hand move away from the end of the hour hand at the fastest rate?

Note: Try solving this one without using calculus. 'Logical reasoning' will get you the solution much more easily than calculus.

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ANSWERS

Answer 1 V_{cm} *= 3/4 units, Force = 1/2 units.*

Answer 2 **The chain falls keeping its original shape and speed.**

Answer 3 **Broader worm does more work than the narrow worm. The ratio of the amounts of work done is 2:3.**

Answer 4 **(a)** $v_{min} = \frac{2\pi r_1}{N_1 f}$, $N_2 = \frac{3N_1}{2}$

(b) **where** $\phi = \frac{\pi}{3}$.

Answer 5 **11 minutes past midnight (Approx)**

For detailed solutions and more challenge problems, see Insight notice board