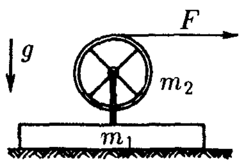
ADVANCED PHYSICS CLUB

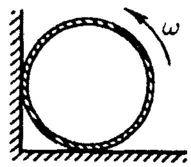
MARCH 8, 2020

Last Homework

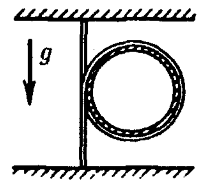
Here are few partial solutions and hints to help you solving the problem assigned last time



To HW problem 1



To HW problem 2



To HW problem 3

1. On a horizontal frictionless table there is a block of mass m_1. Installed upon it there is a thin-walled cylinder of mass m_2 and radius R which could rotate around its' axis without friction. There is a thin weightless thread wrapped around the cylinder, as shown on a picture. Find cylinder's angular acceleration and block's linear acceleration if the thread is pulled with force F.

Solution: As F is the only horizontal force acting on the system $m_1 + m_2$ the linear acceleration of the block is $a = F/(m_1 + m_2)$. Similarly F is the only force creating torque on the cylinder (obvious in the non-inertial reference frame). Therefore, $FR = \alpha m_2 R^2$ and $\alpha = F/(m_2 R)$.

2. A thin-walled cylinder of radius R rotating with initial angular velocity ω is placed in a corner, as shown on a picture. Friction coefficient between the sides of the corner and the cylinder is μ. Find how many times will the cylinder rotate around its' axis before stopping.

Solution: Consider all forces acting on the cylinder. Denote N_1 and N_2 the normal forces from the left wall and floor, respectively. The corresponding friction forces are μN_1 and μN_2 and they are directed upwards and to the left, respectively. The net force acting on the cylinder is zero. Solve for $N_{1,2}$ using this condition for horizontal and for vertical forces (do not forget the gravity force mg). The total torque slowing down the rotation is $(\mu N_1 + \mu N_2)R = -\alpha m R^2$. This determines the angular acceleration α. Finally the total angle of rotation before stop $\theta = \omega^2/(2\alpha)$ and the number of rotations is $n = \theta/(2\pi)$.

Answer: $n = \frac{\omega^2 R}{g} \frac{1+\mu^2}{4\pi\mu(1+\mu)}$.

***3.** A uniform heavy rope with ends fixed along the same vertical line is grasped around a weightless ring. What is the acceleration of the ring if it's just let go from the rest?

Hint: Assume that the ring is displaced by h. Then the change of potential energy of the rope is mgh. If the velocity of the ring at this point v what is its full kinetic energy (some of translational and rotational)? Equate these energies and find v. Compare with the standard formula $v = \sqrt{2ah}$ and deduce the value of a.

Answer: $a = g/2$.

Homework problems

It seems that the most difficult problem of the A-exam for our club was the problem 20. Then, three problems 3, 13, 22 presented significant difficulties. Here is the assignment.

1. Try to solve again the problems 20, 3, 13, 22 of the Exam A of F=ma 2020 and check your solutions with the official solutions here:

`https://www.aapt.org/physicsteam/2020/upload/2020-Fma-Exam-A_solutions_v2.pdf`

2. Do the same with the problems 1, 6, 7, 8, 16, 25.

Important

The club will not meet physically until the next academic year. We will continue by correspondence. The discussion of old problems and new assignments will be posted on the web site on Sundays. Feel free to send your solutions, questions, comments, ideas to apc@schoolnova.org. You can always find the list of all assignments and updates on the web site:

`https://schoolnova.org/nova/classinfo?class_id=adv_phy_club&sem_id=ay2019`