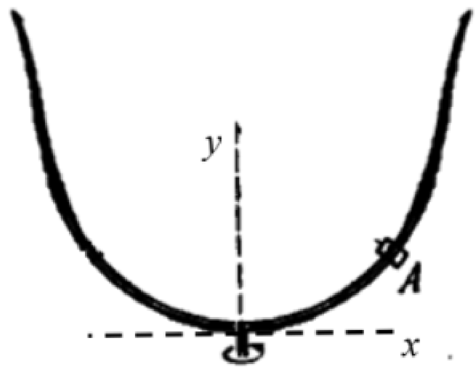
Indonesian Physics Olympiad Selection Test 2020 District Stage

Translated by Sayed Aulia

1. (8 Points)

An object A can move without friction along a parabolic shaped wire that fulfils the equation $y = ax^2$ with x as the horizontal distance from the wire symmetrical axis, and y is the height of the object from the lowest point. If the wire is spun with angular velocity ω with y as its axis, determine the value ω (declared in g and a) so that the the object is in steady position!



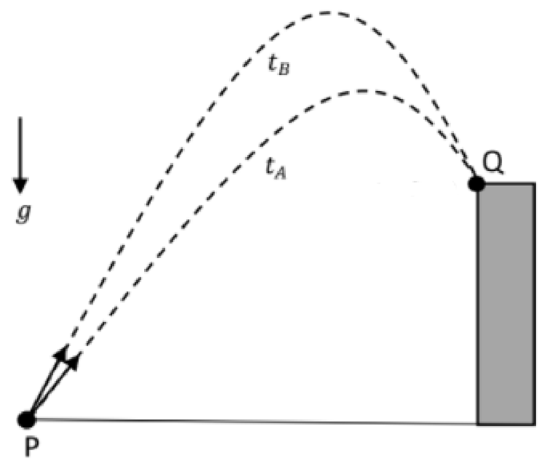
2. (10 points)

For four days in a row, a child started to leave from home by walking to school and he always leave in the same time. The school bell is set to ring always in the same time.
· In the first day, the child started to walk with an initial velocity 50 meter a minute and accelerated with a constant acceleration of 2 meter per minute. It is happened that he arrived 5 minutes after the bell rang.
· In the second day, the child started to walk with an initial velocity 150 meter a

minute and decelerated with a constant deceleration of 2 meter per minute. It is happened that he arrived 5 minutes before the bell rang.
· In the third day, the child decided to walk with a constant velocity (Which value is greater than 100 meter per minute) till he arrived to school. It is happened that he arrived in time.
If in the fourth day he walked with a constant velocity of 100 meter per minute, at what time will he arrived at school after the bell rang.

3. (10 points)

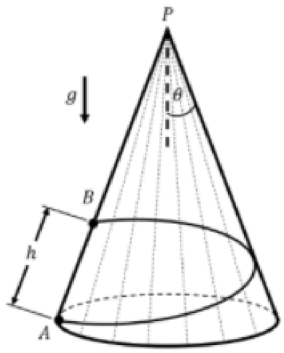
Two children wanted to throw balls so that they hit a point at the edge of a cliff. They stand at a launch point at a certain distance from the target. They throw the balls with the same initial velocity at the same time, but with a different angle of elevation so that the time it take for ball one and ball two to hit the target are t_A and t_B respectively. It is known that the acceleration of gravity at that place is g. Determine the distance PQ from the launch point to the target (Declared in t_A and t_B)!



4. (12 points)

A mountain is modeled as a cone with height H and half opening angle of θ, where $\sin\theta = \frac{1}{4}$. A path that circles around the mountain is made to connect point A at the bottom of the mountain and point B at the surface of the mountain, where the summit of the mountain (Point P), point A and point B are located in a certain straight line. The length of segment $\overline{AB}$ is $h = \frac{H}{\sqrt{15}}$. The path is made using a wire with minimum length that circles the mountain. A particle that can move freely without friction along the wire path is shot from point A and move toward B. Declare your answer in H and acceleration of gravity g.

a. Determine the minimum initial speed of particle at point A, which is v so that it can reach point B.
b. If particle is shot from point A with the following speed v, calculate the speed of the particle at point B which is v'



5. (15 points)

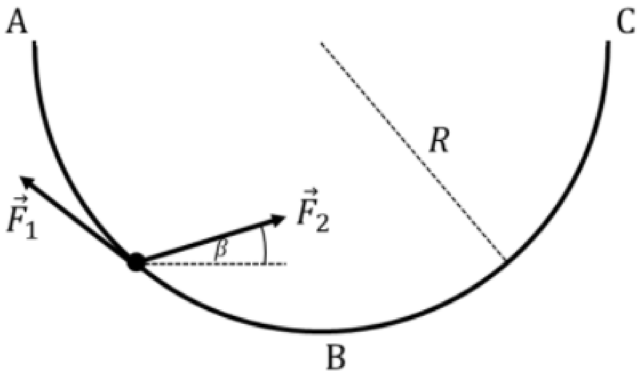
Tho object of masses m_1 and m_2 ($m_1 > m_2$) is collinear and located above a rough flat surface with the same coefficient friction static and kinetic which value is μ. Initially object 1 is located on the left side of object 2, that is stationary, with distance L and imparted a velocity with magnitude v_1 to the right.
a. Determine the requirement that is needed for the first object to collide with the second object. If the requirement is fulfilled then object 1 will collide with object 2. Assume that the collision happened instantaneously so that the collision is perfectly elastic.
b. Determine where the final position of object 1 is by considering the collision position as the center of coordinate!
c. Determine where the final position of object 2 is by considering the collision position as the center of coordinate!
d. What is the distance of the two objects when they have stopped? Assume that the volume of the object is very small compared to the distance they have travelled.

6. (15 points)

A particle with mass m slides on top of a curved smooth metal ABC (point B is located at the lowest point of the trajectory that is shaped as a half circle with radius R (see figure). During the particle sliding through the curve, two forces $\vec{F_1}$ and $\vec{F_2}$

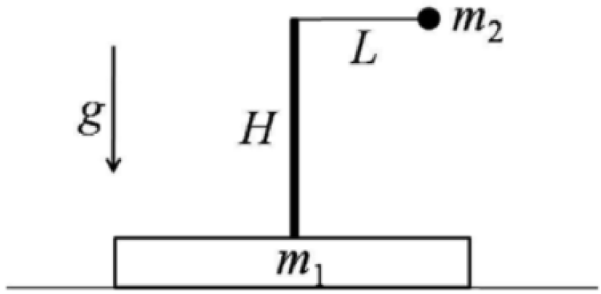
are acting on the particle. It is known that magnitude of both forces are constant, the direction of $\vec{F_1}$ always tangent to the curve, whereas the direction of $\vec{F_2}$ is always constant and make angle β with the horizontal. If the particle is released from point A, and the acceleration of gravity is g, determine:

a. The total work by $\vec{F_1}$ and $\vec{F_2}$ when particle arrived at point B. Declare your answer in F_1, F_2, R, m, g and β.
b. The magnitude of the contact force between mass m with the curve in point B. B. Declare your answer in F_1, F_2, R, m, g and β.
c. The magnitude of force $\vec{F_2}$ if the speed of the particle at point C equals to zero. Declare your answer in F_1 and β.
Hint: $\int \sin x \, dx = -\cos x + C$ and $\int \cos x \, dx = \sin x + C$



7. (15 points)

A bar of mass m_1 is located above a smooth surface. In the bar there exist a firm pole with height H which mass can be ignored. There exist a pendulum system which consists of a small ball of mass m_2 which is suspended by a firm rope with no mass with length L ($< H$). The pendulum can swing freely without friction at the top edge of the pole. Initially the position of rope is parallel with the horizontal, then the system move without initial velocity. Acceleration of gravity g is directed to the bottom. Determine:
a. The tension of the rope as a function of θ which is an angle between the rope and the pole;
b. The maximum value of the tension and the velocity at that point.



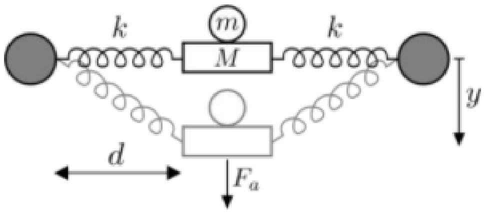
8. (15 points)

Slingshot is a children's toy that is used to shoot small rock. Commonly slingshot is made from a double branched handle which both ends are tied with a rubber (spring). In designing a slingshot, there exist two configurations (see figure). In configuration I, the natural length of the spring is shorter than the distance from the branch to the bearing ($l_0 < d$). In configuration II, the natural length of the spring is greater than the distance from the branch to the bearing ($l_0 > d$). To shoot a rock with mass m, a child pulls the bearing of the rock with mass M to the distance y with force F_a, then releasing it. Assume that the rubber has spring coefficient k and it fulfills Hooke's law.

a. Find the velocity of the rock throw v in the extreme case in configuration I ($l_0 << d$) and configuration II ($l_0 >> d$)! Declare your answer in variable F_a, k, m, and M!

b. Coefficient of spring of the slingshot's rubber can also be declared with the equation $k = EA/L$, where E is a coefficient that depends with the material of the rubber (Young's modulus), A is the area of the cross section of the rubber, and L is the length of the "Section" of the rubber. If the child used the same material and the same area of the cross section, determine whether it is better for the child to cut the following rubber as the configuration I or configuration II!

Configuration I ($l < d$)



Configuration II ($l > d$)