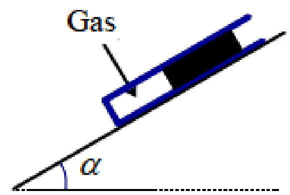
Multiple choice questions (Select one answer in each question.)

1. Spaceship-A moves at velocity $40(\vec{x_0} + \vec{y_0})$ km/s relative to a fixed coordinate system. Spaceship-B moves at $30(\vec{x_0} - \vec{y_0})$ km/s as seen by Spaceship-A. Find the velocity of Spaceship-B in the fixed coordinate system in the unit of km/s.

   (a) $10\vec{x}_0 + 10\vec{y}_0$ (b) $10\vec{x}_0 + 70\vec{y}_0$ (c) $10\vec{x}_0 + 10\vec{z}_0$ (d) $70\vec{x}_0 + 10\vec{y}_0$
   (e) $10\vec{x}_0 - 10\vec{y}_0$

2. A light glass tube with a sealed lower end and cross section area S = 2.5 cm^2 contains a column of mercury of mass m = 2 kg. Between the mercury and the lower end is some trapped gas. The glass tube is sliding down a slope with an inclining angle α = 30°. The dynamic friction coefficient between the tube and the slope is $\mu = \sqrt{3}/6$. Find the pressure of the trapped gas in terms of the standard atmosphere pressure p_0.

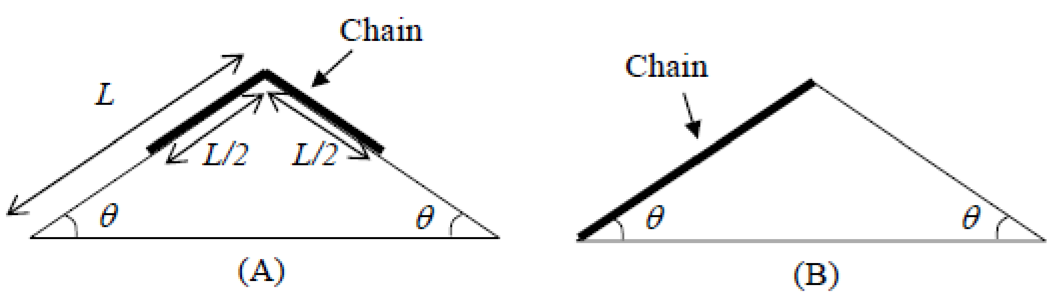


   (a) 1.7 (b) 1.2 (c) 1.9 (d) 2.3 (e) 16

3. Saturn revolves around the sun at 29.5 years per revolution. Find the distance between Saturn and Sun in terms of astronomical units (A. U.).

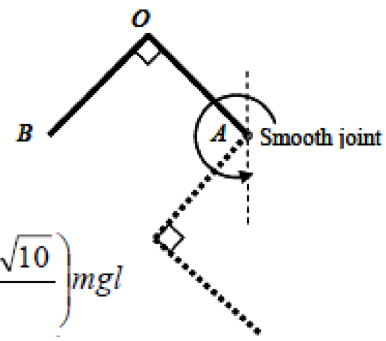
   (a) 5.2 (b) 9.5 (c) 11.9 (d) 15 (e) 3.0

4. A uniform chain of mass m and length L is originally placed mid-way on the top of a fixed smooth double-sided wedge (Figure-A). The length of each side of the wedge is L. It is then given a slight push. Find the kinetic energy of the chain when the whole chain has just slid to the left side of the wedge (Figure-B).



   (a) $mgL\sin\theta$ (b) $\dfrac{mgL\sin\theta}{2}$ (c) $\dfrac{mgL\sin\theta}{4}$ (d) $\dfrac{mgL\sin\theta}{8}$
   (e) $2mgL\sin\theta$

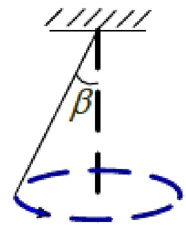
5. A uniform "L"-shaped rigid body AOB of mass m, where $AO = OB = l$ and $\angle AOB$ is a right angle, is hinged to a smooth joint at Point A of the body and can swing freely in a vertical plane. Initially, the body is released from rest with AB horizontal. Find the ***maximum kinetic energy*** of the body.



(a) $\left(\frac{\sqrt{2}+\sqrt{10}}{4}\right)mgl$ (b) $\left(\frac{\sqrt{2}+\sqrt{5}}{2}\right)mgl$ (c) $\left(\frac{\sqrt{3}+\sqrt{10}}{4}\right)mgl$

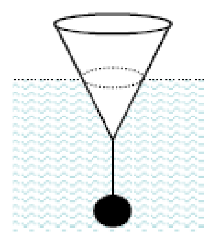
(d) $\left(\frac{\sqrt{3}+\sqrt{5}}{2}\right)mgl$ (e) $\left(\frac{\sqrt{2}}{2}\right)mgl$

6. As shown, one end of a light thread is fixed on the ceiling and the other end tied to a small sphere. The angle between the thread and the vertical direction is β. When β = α and α is a small angle, the sphere is in simple harmonic motion like a pendulum with period T. When β = α_1 or α_2 ($\alpha < \alpha_1 < \alpha_2$), the sphere is in a uniform circular motion in a horizontal plane with period T_1 or T_2, respectively. Then the correct relation is________.



(a) $T < T_1 < T_2$ (b) $T = T_1 = T_2$ (c) $T > T_1 > T_2$ (d) $T_1 < T < T_2$
(e) $T_1 > T > T_2$

7. A cone of height H with a mass attached is floating upside down in water, as shown. The water reaches $H/2$ when in equilibrium. Ignore friction. Find the vibration frequency after the cone is slightly pushed downwards.



(a) $\frac{1}{2\pi}\sqrt{\frac{6g}{H}}$ (b) $\frac{1}{2\pi}\sqrt{\frac{g}{H}}$ (c) $\frac{1}{2\pi}\sqrt{\frac{3g}{H}}$
(d) $\frac{1}{2\pi}\sqrt{\frac{8g}{H}}$ (e) $\frac{1}{2\pi}\sqrt{\frac{2g}{H}}$

8. Object-A is dropped from a height h. At the same instant object-B is thrown vertically upward from the ground. Right before they collide in mid-air, the speed of A is twice the speed of B. Determine the height where the collision occurs.

(a) $\frac{2h}{3}$ (b) $\frac{h}{\sqrt{3}}$ (c) $\frac{3h}{4}$ (d) $\frac{h}{2}$ (e) $\frac{h}{4}$

9. An object of mass m is placed on a horizontal floor. The static friction coefficient between the object and the floor is $\mu = 1$. Find the minimum force that can move the object.

(a) $\frac{mg}{2}$ (b) $\frac{mg}{\sqrt{2}}$ (c) mg (d) $\sqrt{2}\,mg$ (e) $2mg$