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

1. As shown in Fig. 1, a boy is riding on a bus. The bus moves with a uniform speed of 20 km/h in a horizontal circle, and the traffic light is located at the center of the circle. What is the velocity of the traffic light relative to the boy?
   a. 20 km/h in the forward direction of the bus
   b. 20 km/h in the backward direction of the bus
   c. 20 km/h perpendicular to the forward direction of the bus and directed away from the bus
   d. 20 km/h perpendicular to the forward direction of the bus and directed towards the bus
   e. 0 km/h

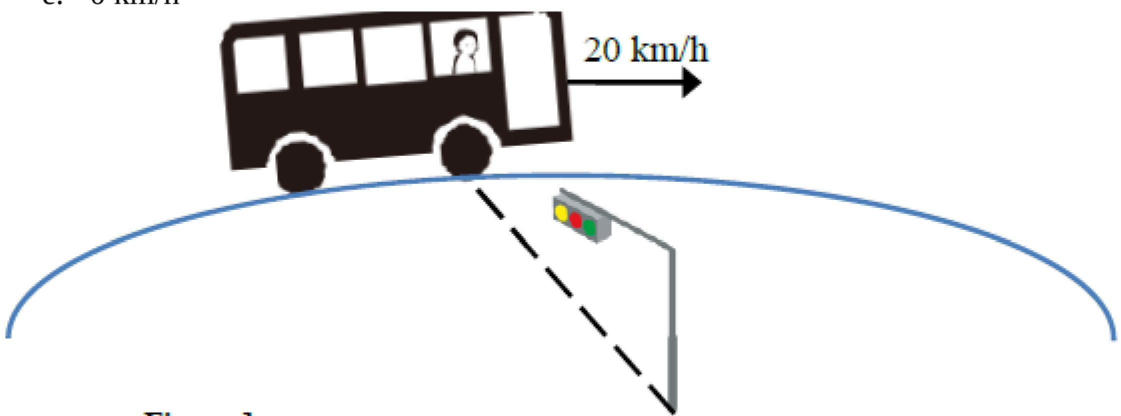


Figure 1

2. A tennis ball machine is installed on the bus in Fig. 1. It projects tennis balls at a speed of 100 km/h in the direction perpendicular to the forward direction of the bus, and on the outward side of the circular path. The trajectories of the tennis balls observed by the boy are
   a. straight lines perpendicular to the forward direction of the bus
   b. straight lines slightly inclined towards the forward direction of the bus
   c. straight lines slightly inclined towards the backward direction of the bus
   d. curves slightly inclined towards the forward direction of the bus
   e. curves slightly inclined towards the backward direction of the bus
3. A man sits in the back of a canoe in still water. He then moves to the front of the canoe and sits there. Neglecting the damping of water, the final position and the motion of the canoe is:
   a. forward of its original position and moving forward
   b. forward of its original position and moving backward
   c. rearward of its original position and moving forward
   d. rearward of its original position and moving backward
   e. rearward of its original position and not moving
4. A boat is about to cross a river to the opposite bank. The river water flows at a speed of 4 km/h. If the speed of the boat is 3 km/h, what should be the angle between the boat velocity and the upstream direction of the river, so that the downstream displacement is minimum when the boat reaches the opposite bank?
   A) $0°$ B) $37°$ C) $41°$ D) $53°$ E) $90°$

5. *In a talent show, a juggler juggles 4 balls simultaneously, as shown in Fig. 2. A spectator uses his high speed video tape and determines that it takes the juggler 0.9 s to cycle each ball through his hands (including catching, transferring and throwing) and to be ready to catch the next ball. It is noted that at most one ball must be in a hand of the juggler in each cycle of juggling. What is the minimum vertical speed the juggler must throw up each ball?

A) 9.3 m/s B) 11.4 m/s C) 12.8 m/s D) 13.2 m/s E) 17.6 m/s

6. As shown in Fig. 3, the block-spring system is in equilibrium provided that the left spring is stretched by x_1. The whole system rests on a smooth supporting surface. The coefficient of static friction between the blocks is μ_s, and the blocks have equal mass m. What is the maximum amplitude of the oscillations of the system such that the top block does not slide on the bottom one?

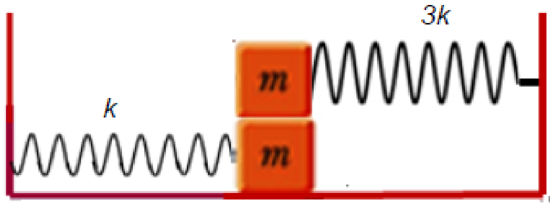
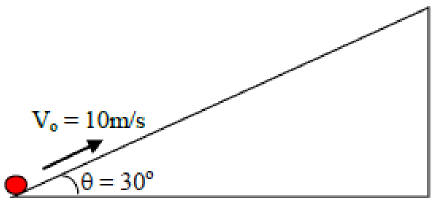


Figure 3

A) $\frac{\mu_s mg}{2k} + x_1$ B) $4kx_1 - \mu_s mg$ C) $\frac{\mu_s mg}{k} - x_1$ D) $2(2kx_1 + \mu_s mg)$ E) $2(2kx_1 - \mu_s mg)$

7. An object is projected up an inclined plane with an initial speed of $v_0 = 10$ m/s, as shown. The angle of the incline is $\theta = 30^\circ$ above the horizontal direction and the coefficient of the sliding friction $\mu_k = 0.1$, determine the total time for the object to return to the point of projection.



A) 3.81 s B) 4.26 s C) 4.54 s D) 4.94 s E) 5.32 s

8. As shown Fig. 5, a train with a length of L = 500 m moves by its inertia through the horizontal section of a railroad. However, the train encounters a small hill that slopes gently. With what minimum speed v can the train cross the hill? The base of hill has a length l = 100 m, the lengths of the slopes are l_2 = 80 m and l_2 = 60 m. The slopes of hill can be considered as straight lines and the small section of rounding at the top of the hill can be ignored. Neglect any friction.

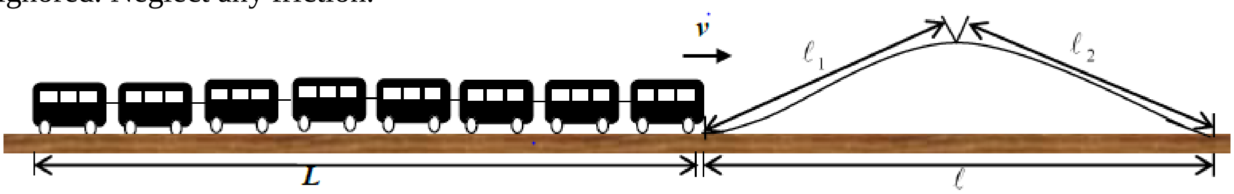


Figure 5

A) 9.6 m/s B) 11.5 m/s C) 13.2 m/s D) 15.0 m/s E) 16.2 m/s

9. It is given the mass of Earth is a times that of Moon, and the radius of Earth is b times that of Moon. The period of a simple pendulum is T. When it is carried to Moon, the period of the simple pendulum becomes:

   A) $\frac{a}{\sqrt{b}}T$ B) $\frac{\sqrt{b}}{a}T$ C) $\frac{\sqrt{a}}{b}T$ D) $\frac{b}{\sqrt{a}}T$ E) $\sqrt{\frac{b}{a}}T$

10. There exist some triple star systems in the universe. They are more distant from other stars, and are composed of three stars of equal mass M. The gravitational forces due to other stars can be neglected. A basic stable structure of triple star systems consists of three collinear stars, with two companion stars moving around a central star on a circular orbit with radius R. The linear velocity of the companion stars is $v_1 = k_1\sqrt{GM/R}$, where $k_1 =$

    A) $\sqrt{10}$ B) $\sqrt{5}$ C) $\sqrt{5/2}$ D) $\sqrt{5}/2$ E) $\sqrt[3]{5/2}$