

PART II: FREE-RESPONSE (“SHOW-YOUR-WORK”) PROBLEMS

For Questions 13-19, write your answers in the spaces provided. If you need additional space, ask your instructor for scratch paper. **You must answer each part of the question completely and show all of your work in any calculations to receive full credit.**

13. In a game at a carnival, a contestant rolls a ball up the slope shown in Figure 1 with an initial speed v_i . The object of the game is to roll the ball in such a way that it will get “stuck” in the depression at B and not return back down the slope. This will happen if the ball’s speed when it gets to point A is essentially zero, as shown in the figure. (The speed of the ball at point A really has to be *greater* than zero in order for the ball to make it past point A , but the speed at point A must be greater than zero only by an arbitrarily *small amount*, so that we can say that the condition for the ball not to return is *essentially* that the speed at A must be zero.) Assuming that the ball rolls without slipping and that energy losses due to friction are negligible, find the initial speed v_i required to make the speed of the ball at point A zero. Let the mass of the ball be called M and let the radius of the ball be called R . Treat the ball as a solid sphere. (10 points)

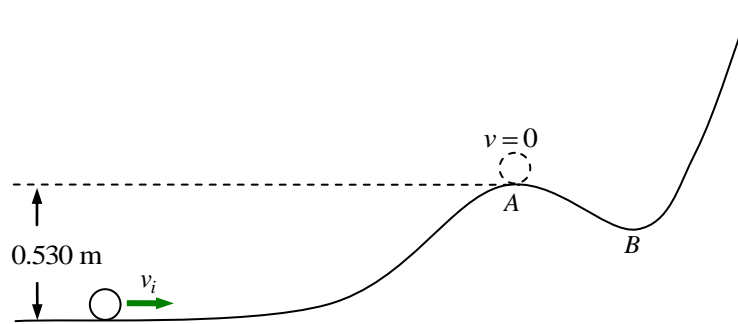


Figure 1

14. (a) Two masses, m_1 and m_2 , undergo an elastic head-on collision. Just before the collision, m_1 is moving with a speed of 4.0 m/s to the right, while m_2 is moving with a speed of 1.0 m/s to the left. If m_1 is three times larger than m_2 , find the velocities of the two masses just after the collision. (5 points)

(b) A 50.0-kg skater is traveling due east at a speed of 3.00 m/s. A 70.0-kg skater is moving due south at a speed of 7.00 m/s. They collide and hold on to each other after the collision, managing to move off at an angle θ south of east, with a speed v_f . Find the angle θ . (Assume that any friction forces are negligible.) (8 points)

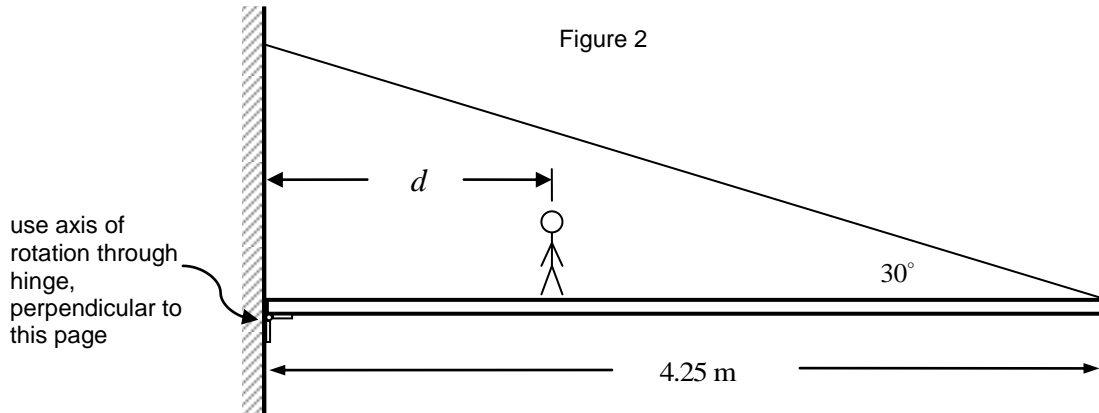
15. 330 g of water at 45°C are poured into an 855-g aluminum container with an initial temperature of 10°C. What is the final equilibrium temperature of the system, assuming no heat is exchanged with the surroundings? (10 points)

Note: $c_{\text{Aluminum}} = 900 \text{ J/ kg} \cdot ^\circ\text{C}$ and $c_{\text{water}} = 4186 \text{ J/ kg} \cdot ^\circ\text{C}$.

16. What is the launch speed of a projectile that rises vertically above the Earth to a maximum altitude (above the surface of Earth) that is equal to two Earth radii? (Neglect air resistance.) (10 points)

17. A star of radius $R = 2.3 \times 10^8$ m rotates with an angular velocity $\omega_i = 2.4 \times 10^{-6}$ rad/s. If this star collapses to a radius of 20.0 km, find its final angular velocity. (Treat the star as if it were a uniform sphere. Assume that no external torques act on it and that no mass is lost as the star collapses.) (10 points)

18. A 47.0-kg uniform thin plank 4.25 m long is hinged to a vertical wall, as shown in Figure 2 below. A 68.0-kg person stands on the plank, and the plank is held in equilibrium by a wire attached to the right end, as shown. The wire makes an angle of 30° with the plank, as shown in the figure. If the maximum tension that the wire can withstand before breaking is 1400 N, to what maximum distance d_{max} (measured from the left end) can the person walk without causing the wire to break? (Take the axis of rotation of the plank to be through the hinge and perpendicular to the page, as indicated in Figure 2.) (10 points)



19. An object moving in the x - y plane has a net force acting on it given by $\vec{F}_{net} = \langle \alpha x^2, \beta y \rangle$, in which $\alpha = 2.0 \text{ N/m}^2$ and $\beta = 3.0 \text{ N/m}$.

a) Calculate the net work done on the object as it moves from the point $\vec{r}_i = \langle 0, 0 \rangle$ to the point $\vec{r}_f = \langle 5.0 \text{ m}, 0 \rangle$. (8 points)

b) If the object starts from rest and has mass 6.0 kg , calculate its final speed. (5 points)