BRAC UNIVERSITY

Principles of Physics-I (PHY-111)

Department of Mathematics and Natural Sciences

Assignment: 03 — **Section**: 36

Duration: 8 Days | **Summer 2023 (UB41403)** | Marks: 25

Attempt all three questions. Show Your work in detail. 1:1 plagiarism will be penalized.

1. A small remote-controlled car with mass 1.60 kg moves at a constant speed of $v = 12\,\mathrm{m\,s^{-1}}$ in a track formed by a vertical circle inside a hollow metal cylinder that has a radius of 5.00 m.

   (a) Is the Centrifugal force real? If yes, why? If not, why not? Briefly explain in 1-2 sentences. **(1)**

   Centrifugal force is not a fundamental force but rather an apparent or fictitious force that arises in a rotating frame of reference. It is perceived as an outward force pulling objects away from the center of rotation. You can not draw it in a free-body diagram because it doesn't exist.

   (b) What is the magnitude of the normal force exerted on the car by the walls of the cylinder at the bottom of the track? **(2)**

   Apply Newton's 2nd law in the free-body diagram. A diagram is a must in this answer.

$$\sum F_y = N_B - W = +\frac{mv^2}{R}$$
$$N_B = mg + \frac{mv^2}{R} = 61.776\,\mathrm{N}.$$

   (c) What is the magnitude of the normal force exerted on the car by the cylinder walls at the top of the track? **(3)**

   Apply Newton's 2nd law in the free-body diagram. A diagram is a must in this answer. The is upside down so N_T must be downward.

$$\sum F_y = -N_T - W = -\frac{mv^2}{R}$$
$$N_T = \frac{mv^2}{R} - mg = 30.384\,\mathrm{N}.$$

   (d) How long does the car take to complete six revolutions around the track? Find the *rpm* (revolutions per minute) value. **(4)**

$$T = \frac{2\pi R}{v} = 2.6167\,\mathrm{s} \sim 23\,(\text{in rpm}).$$
$$6\,\text{revolutions} \equiv 6T = 15.700\,\mathrm{s}.$$

2. A flat (unbanked) curve on a highway has a radius of 230 m. A car rounds the curve at a speed of $28\,\mathrm{m\,s^{-1}}$. The road is 4 m wide.

   (a) What is the minimum coefficient of static friction that will prevent sliding? **(1)**

$$\mu = \frac{v^2}{gR} = 0.3475.$$

(b) Suppose that the highway is icy and the coefficient of static friction between the tires and pavement is only one-third of what you found in part (a). What should be the maximum speed of the car so that it can round the curve safely? **(2)**

$$v = \sqrt{gR\frac{\mu}{3}} = 16.166\,\mathrm{m\,s^{-1}}.$$

(c) The road is now banked by an angle of 30°. If the car moves at three times the speed found in (b), what is the new coefficient of static friction? **(2)**

$$\mu = \frac{v^2 - gR\tan\theta}{v^2\tan\theta + gR} = 0.2899.$$

3. A baseball has a mass of 0.145 kg. In batting practice, a batter hits a ball sitting at rest on top of a post. The ball leaves the post with a horizontal speed of $30\,\mathrm{m\,s^{-1}}$.

(a) If there is a net nonzero force on a moving object, can the total work done on the object be zero? Explain, using an example. **(1)**

If there is a net nonzero force on a moving object, the total work done on the object cannot be zero. This is because work is directly related to force and displacement, and if there is a net force acting on an object, it will result in a change in its kinetic energy, and thus work must be done.

(b) How much work did the force applied by the bat do on the ball? **(2)**

$$W = \Delta K = \frac{1}{2}mv^2 = 65.25\,\mathrm{J}$$

(c) During a game, the same batter swings at a ball thrown by the bowler and hits it so that the ball moves away from him horizontally. Just before the ball is hit, it is traveling at a speed of $20\,\mathrm{m\,s^{-1}}$, and just after it is hit, it travels in the opposite direction at a speed of $30\,\mathrm{m\,s^{-1}}$. Find the impulse applied to the ball. **(3)**

$$J = \Delta p = p_f - p_i = m(v_f - v_i) = 7.25\,\mathrm{J}.$$

(d) What is the total work done on the baseball by the force exerted by the bat? How does this result compare to the one from (b)? Find the average force the ball was hit with if the bat only was in contact for 2 ms. **(4)**

$$W = \frac{1}{2}m(v_f^2 - v_i^2) = 36.25\,\mathrm{J}.$$

$$F_{\mathrm{avg}} = \frac{J}{\Delta t} = 3625\,\mathrm{N}.$$