Midterm 3 for Algebra-Based Physics-1: Mechanics (PHYS135A-01)

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1 Rotational Kinematics and Dynamics

1. Express the following angles in radians: (a) 180° (b) 90° (c) 120° (d) 270°

2. A man spins a grindstone to sharpen a knife, and can accelerate the grindstone with a foot pedal. Suppose the grindstone has a radius $r = 5$ cm, and is spinning initially at 60 rpm. (a) If he presses the foot pedal and the angular velocity increases from 60 rpm to 120 rpm in 2 seconds, what is the angular acceleration?

3. A centrifuge for separating dissolved solids in a liquid is shown in Fig. 1. The tangential velocity is $v = 10$ m/s, and the radius is $r = 4$ cm. (a) What is the angular velocity? (b) What is the centripetal acceleration at the location indicated by the arrow? (c) How many g's is the centripetal acceleration?

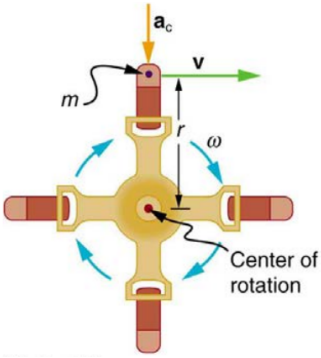

Figure 1: A centrifuge undergoes uniform circular motion, with tangential velocity v and radius r.

4. A car traveling along a banked curve with radius r is illustrated in Fig. 2. (a) Show that if the net force is zero as the car goes through this curve of radius r, that the speed of the car is $v = \sqrt{rg \tan\theta}$. (b) What is v, if $r = 600$ m, $g \approx 10$ m/s^2, and $\theta = 10^\circ$?

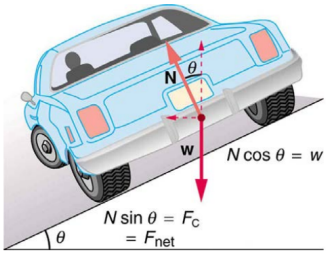

Figure 2: A vehicle travels along a banked curve, hugging the road.

2 Newton's Law of Gravity

1. Consider Fig. 3, in which a planet orbits a star. Suppose that the acceleration due to gravity on the surface of the planet is a. (a) Show that $a = GM_p/d^2$, where G is Newton's constant. (b) What is M_p, if $a = 7.6$ m/s^2, and $d = 5000$ km? (c) Show that if the period of the orbit of the planet around the star is T, that $M_S = 4\pi^2 b^3/T^2$. (d) If $b = 3 \times 10^{11}$ m (about 2 AU), and $T = 2$ years, what is M_P?

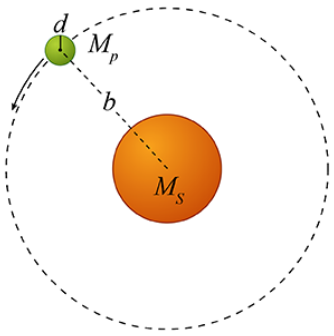

Figure 3: A planet of mass M_P and radius d orbits a star of mass M_S at an orbital radius b.

2. What is the orbital period of Neptune, T_N, if the orbital radius of Neptune, r_N, is 30 AU? (Recall that $T_{Earth} = 1.0$ year and $r_{Earth} = 1.0$ AU).

3 Work and the Work-Energy Theorem

1. Consider Fig. 4. (a) Explain in your own words why the work done *on the briefcase* by the man is zero Joules for each case. (b) Now suppose there is work being done. If the force vector is $\vec{F} = 3\hat{i} + 3\hat{j}$ N, and $\vec{d} = 3\hat{i}$ m, what is the work W?

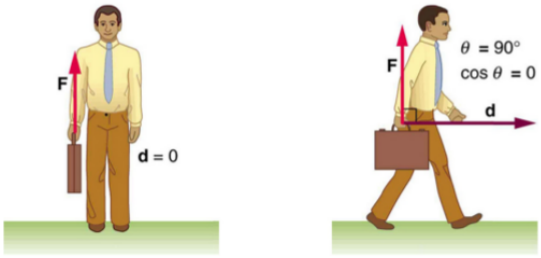

Figure 4: A man holds a briefcase, with different displacements and forces.

2. (a) If a person throws a 0.145 kg baseball at $v = 10$ m/s, what is the kinetic energy of the baseball? (b) If a person drops a 0.145 kg baseball from a building that is 30 m tall, what is the final speed of the baseball?

3. What is the final velocity of the roller coaster cars in Fig. 5?

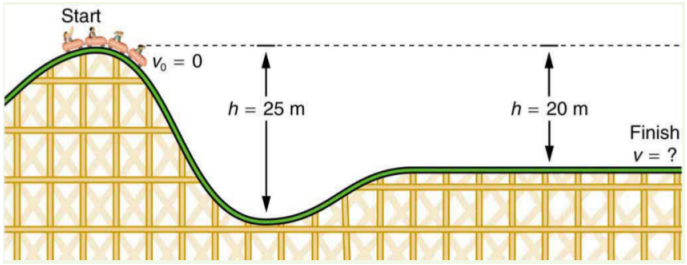

Figure 5: A roller coaster starts with no initial velocity, but ends with velocity v.