FINAL EXAM REVIEW FOR PHY 2053 – COLLEGE PHYSICS 1

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*I included some notes that include the definitions of the subject from the openstax.org College Physics 2e textbook.

KINEMATICS

Notes

Kinematics is defined as the *study of motion without considering its causes.*

1. Make a set of instructions for yourself on how to approach a kinematics problem.

2. A rock is tossed **horizontally** from the edge of an **80.0 m cliff** and lands **120.0 m** away from the base of the cliff. Assume negligible air drag.
    a. What horizontal velocity must the rock have been thrown with?
    b. How long does the rock remain in the air?
    c. What is the rock's **vertical velocity component** just before it strikes the ground?
    d. Determine the **magnitude and direction** of the rock's velocity just before impact.

DYNAMICS

Notes

Dynamics considers the forces that affect the motion of moving objects and systems. Newton's laws of motion are the foundation of dynamics.

1. What are Newton's Laws?
    a.

2. Make a set of instructions for yourself on how to approach a dynamics problem.
    a.

3. A **20.0 kg box** rests on a **30° incline**. The coefficient of **kinetic friction** between the box and the incline is **0.15**. A rope is attached to the box and **pulls it up the incline** at a constant velocity. The rope makes an angle of **20° above the incline**.
    a. Draw a **free-body diagram** for the box, labeling all forces: gravity, normal force, friction, and tension.
    b. Calculate the **component of gravity parallel to the incline** and **component perpendicular to the incline**.
    c. Find the **normal force** exerted by the incline on the box.
    d. Determine the **frictional force** acting on the box.
    e. Calculate the **tension in the rope** needed to move the box **up the incline at constant velocity**.

UNIFORM CIRCULAR MOTION

Notes

Uniform circular motion is the motion in a circular path at constant speed. The acceleration of an object moving in uniform circular motion (resulting from a net external force) is the **centripetal acceleration**(a_c). Any net force causing uniform circular motion is called a **centripetal force**. The direction of a centripetal force is toward the center of curvature, the same as the direction of centripetal acceleration.

1. If you were to draw a free-body diagram of a system exhibiting uniform circular motion, would you draw a vector representing the centripetal force like you would any other force, for example, the force of gravity?
2. A **2.5 kg toy car** drives on a perfectly circular track of radius **3 m** at a **constant speed of 3.5 m/s**.
    a. Calculate the **centripetal acceleration** of the toy car.
    b. Determine the **centripetal force** acting on the toy car.

WORK-ENERGY

Notes

Formally, the **work** done on a system by a constant force is defined to be the product of the component of the force in the direction of motion times the distance through which the force acts. An important characteristic is that the work done by a nonconservative force *adds or removes mechanical energy from a system*.

$$KE_i+PE_i+W_{nc}=KE_f+PE_f.$$

Total energy is constant in any process. It may change in form or be transferred from one system to another, but the total remains the same. **Friction**, for example, creates **thermal energy** that

dissipates, removing energy from the system. Furthermore, even if the thermal energy is retained or captured, it cannot be fully converted back to work, so it is lost or not recoverable in that sense as well.

1. A **12.0 kg shopping cart** is initially at rest on a **horizontal floor**. A person pushes the cart with a constant **force of 100.0 N, accelerating it** over a distance of **5.0 m**. The coefficient of **kinetic friction** between the cart and the floor is **0.10**.
    a. Calculate the **work done by the person**.
    b. Calculate the **work done by the force of gravity.**
    c. Calculate the **work done by friction.**
    d. Determine the net work done on the cart.
    e. Using the **work-energy theorem**, determine the **final speed of the cart**.

LINEAR MOMENTUM

Notes

Linear momentum is defined as the product of a system's mass multiplied by its velocity. Impulse is the same as the change in momentum. Conservation of momentum is violated only when the net external force is not zero. But another larger system can always be considered in which momentum is conserved by simply including the source of the external force.

An **elastic collision** is one that also conserves internal kinetic energy. An **inelastic collision** is one in which the internal kinetic energy changes (it is not conserved). A collision in which the objects stick together is sometimes called a **perfectly inelastic collision** because it reduces internal kinetic energy more than does any other type of inelastic collision. In fact, such a collision reduces internal kinetic energy to the minimum it can have while still conserving momentum.

1. A **0.350-kg rubber ball** is rolling on a smooth floor at **4.50 m/s** when it strikes a wall and **bounces straight back** at **3.60 m/s**. The collision lasts **0.0200 s**.
    a. What is the **average force** exerted on the ball by the wall during the collision?
    b. How much **kinetic energy does the ball lose** in the collision?
    c. What **percentage of the original kinetic energy is lost** during the collision?

TORQUE, STATICS, AND ROTATIONAL MOTION

Notes

Torque is the rotational equivalent of a force.

Kinematics for rotational motion is completely analogous to translational kinematics.

Rotational	Translational	Relationship
θ: angle	x: displacement	$\theta=x/r$
ω: angular velocity	v: velocity	$\omega=v_t/r$
α: angular acceleration	a: acceleration	$\alpha=a_t/r$

To expand our concept of rotational inertia, we define the **moment of inertia** I of an object to be the sum of mr^2 for all the point masses of which it is composed. That is, $I=\sum mr^2$. Here I is analogous to m in translational motion. The relationship in $\tau=I\alpha$, α=net τ/I is the rotational analog to Newton's second law and is very generally applicable.

Work and energy in rotational motion are completely analogous to work and energy in translational motion.

If the torque you exert is greater than the opposing torques, then the rotation accelerates, and the angular momentum increases. The greater the net torque, the more rapid the increase in L. The relationship between torque and angular momentum is exactly analogous to the relationship between force and linear momentum, $F=\Delta p/\Delta t$.

1. What are the two conditions required for a system to be in static equilibrium?

2. A merry-go-round is modeled as a **solid disk** of mass $M = 60.0$ kg and radius $R = 1.20$ m. Kid A stands on one side and pushes tangentially at the rim with a force $F_A = 35.0$ N (trying to spin it counterclockwise). Kid B stands on the opposite side and pushes in the opposite tangential direction with a force $F_B = 50.0$ N. (Kid B can choose *where* to push — at radius r from the center.)
    a. **If the system is in static equilibrium**, at what radius r (measured from the center) must Kid B apply his 50.0-N push so that there is no net torque and the merry-go-round does not start rotating?
    b. Suppose Kid B instead pushes at the rim ($r = R$), so the torques no longer cancel. If initially the merry-go-round is at rest, what is the **angular acceleration** α of the merry-go-round produced by these two opposing pushes? (Use the sign convention that counterclockwise torque/acceleration is positive.)
    c. After some time the merry-go-round is spinning at $\omega_i = 0.800$ rad/s(counterclockwise). A third child of mass $m = 25.0$ kg hops on and sits at radius $r_{\text{child}} = 0.90$ m. Assuming the hop is quick and there are no external torques during that instant, what is the **final angular speed** ω_f of the system after the child sits down? Treat the child as a point mass for inertia.
3. A **solid disk** has mass $M = 4.00$ kg and radius $R = 0.50$ m. It starts from rest and is given a constant angular acceleration $\alpha = 3.00$ rad/s^2 for $t = 6.00$ s.
    a. What is the disk's **angular velocity** ω after 6.00 s?

b. Through what **angle** (in radians) has it rotated in that time?
c. What is the disk's **rotational kinetic energy** at $t = 6.00$ s?

And that's a wrap! Good luck!