PHY 303K - Practice Final

1) Two trains are traveling on parallel tracks. Train A moves at 25 m/s, while Train B starts 200 m behind Train A but accelerates at a constant rate of 2.5 m/s². How long will it take for Train B to catch up to Train A?

2) While playing catch with my dog, I throw a tennis ball from 5 feet off the ground at an angle of 45°. If my dog runs for 10 meters before jumping 5 feet in the air to catch it, what was the magnitude of the ball's initial velocity when it left my hand? (Answer in m/s)

3) The driver of a dump truck notices she left her car keys in the middle of the empty truck bed which is too tall for her to reach. Luckily she can still engage the pistons that raise and lower the bed. What is the magnitude of the frictional force before she reaches the critical angle where the keys slide off the ramp? What must the magnitude of the frictional force be right when the critical angle is reached? Is this larger or smaller than the frictional force before the keys start to slide? Answer in terms of m, g, θ, & μ_s.

4) Santa's sled lands on a roof inclined at 30° with an initial velocity of 2 m/s. If the coefficient of kinetic friction is 0.4, how far does the sled travel before coming to a stop? (No reindeers were harmed in this rough landing.)

5) A Formula 1 car is navigating a circular track with a radius of 80 m and a coefficient of static friction of 0.7. Calculate the maximum speed the driver can achieve without skidding.

6) A hiker pushes a cool looking rock uphill with a force of 120 N at an angle of 25° to the slope. Calculate the work done by the hiker after moving the rock 6 m up the hill.

7) A toy car of mass 1.5 kg is pushed along a track 2 m long with an average force of 5 N. If the car starts from rest, determine its velocity at the end of the track.

8) An elevator motor supplies power to lift a 600 kg load at a constant speed of 2 m/s. What is the average power exerted by the motor?

9) A spring with a spring constant of 8000 N/m is initially stretched by 3 cm. We then stretch it to a total of 10 cm. By how much does this second stretch increase the system's potential energy? (Answer in Joules)

10) A bowling ball of mass 7 kg and a baseball of mass 1 kg are dropped from the top of the leaning tower of Pisa which is approximately 56 m tall. Assuming no air resistance, determine the final velocity of both objects.

11) A cannon of mass 100 kg is placed on a frictionless plank aboard a pirate ship. What is its recoil velocity after shooting a cannonball of mass 10 kg at an enemy ship with a velocity of 10 m/s?

12) A wind turbine with arms of length 10 m was initially locked in place and is now free to rotate. If the wind hits the bottom blade with a velocity of 15 m/s in the direction of rotation, what is the angular acceleration after 3 revolutions? Assume the blades rotate with a constant angular velocity after 1 revolution.

13) A pepper grinder consists of a cylindrical body of radius 2 cm and an outer cylindrically shaped piece of radius 3 cm that grinds the peppercorns when turned in the opposite direction of the body. If I apply a force of 3 N in the clockwise direction to the inner cylinder and a force of 4 N counterclockwise on the outer cylinder, what is the total torque?

14) A spinning record with a radius of 0.15 m and a moment of inertia of 5 kg·m² rotates at 10 rad/s. A coin of mass 0.1 kg is then placed at the very edge of the record. What is the final angular velocity? Treat the coin like a point particle.

15) A bucket of mass m is lowered by an accelerating pulley system. The pulley is a disk of radius r and mass M. Find an expression for the linear acceleration of the bucket.

16) A transverse wave pulse is traveling in the positive y-direction at 3 m/s. It's wave function at time t = 0 s can be expressed as $x(y,\ t = 0) = 2y^2 + 1$. What is $x(y,\ t)$ for some arbitrary time later?

17) An ice cream truck emits a sound at 700 Hz as it passes someone sitting on their porch. If the person hears the frequency as 650 Hz, how fast was the ice cream truck moving? Assume the speed of sound in air is 343 m/s.

18) Trappist-1e is an Earth-sized exoplanet located 40 lightyears from us. On top of being a rocky planet with the same radius as Earth, it also orbits in the habitable zone of its solar system (i.e. its orbital radius is in the range of distances away from its host star where water can exist in liquid form). If Trappist-1e has a mass 0.7 times that of the Earth, how would its acceleration due to gravity compare to ours?

19) A satellite is moved from an orbit of radius 7,000 km to one of radius 10,000 km from the Earth's center. If the satellite's mass is 500 kg, calculate the energy required for this maneuver. Assume Earth's radius is 6,370 km and its mass is 5.972×10^{24} kg.