

X3.0

205

PHYS-205(8) (Kaldon-18454)

Name _____

WMU-Spring 2001

Exam 000 - ~~100,000 points + 20,000 \star points~~ Book Title This is for Topic 1, not your textbook!

Sample - Not a Real Exam

Rev. 10/24/2000.3

State Any Assumptions You Need To Make – Show All Work – Circle Any Final Answers

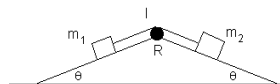
Use Your Time Wisely – Work on What You Can – Be Sure to Write Down Equations

Feel Free to Ask Any Questions

\star 2a \star 2b \star 2c \star 2e

The (Inclined) Plane Truth (25,000 points)

1.) Two masses, m_1 and m_2 , are connected over a real pulley with moment of inertia, I , and radius R , and where $m_1 < m_2$. Setup *But Do Not Solve* the equations from the Free Body Diagrams for (a) m_1 , (b) m_2 and from the Free Rotation Diagram for (c) the pulley. *You must indicate which way the masses and the pulley intend to move, and have the equations properly linked with each other.*



(d) A 5.00 kg ball of radius 0.150 m is rolling along without slipping at 5.00 m/s. Find the total kinetic energy of this ball – both linear and rotational terms.

(e) If this ball rolls into a spring and comes to a stop in 0.280 m, find the spring constant k of the spring.

Odds and Ends (25,000 points)

2.) \star (a) A plate of mass $m = 5.00$ kg has dimensions $a = 1.00$ m and $b = 0.480$ m.

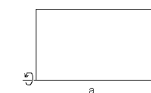
Find the center of mass coordinates x_{cm} and y_{cm} by integrating $x_{cm} = \frac{1}{M} \int x dm$ and

$$y_{cm} = \frac{1}{M} \int y dm.$$

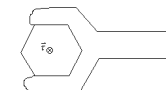


\star (b) A plate of mass $m = 5.00$ kg has dimensions $a = 1.00$ m and $b = 0.480$ m.

Find the moment of inertia I of the plate about an axis along the bottom edge as shown, by integrating $I = \int r^2 dm$.



\star (c) A torque $\vec{\tau}$ to tighten a bolt consists of a force being applied at a distance from the axis of rotation. As the bolt gets tighter, it gets harder and harder to turn the bolt, so the torque as a function of angle is given by $\tau = C \theta$, where C is some constant with appropriate units. If the total work done by applying this torque through two complete revolutions is 1500. J, then find C .



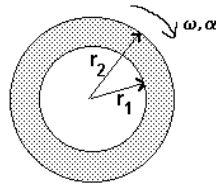
(d) Which way does the bolt turn in (c) if $\vec{\tau}$ points *into* the paper? *Use Right Hand Rule to explain your answer.*

\star (e) Show that the equation $x(t) = A \cos(\omega t) + B \sin(\omega t)$ satisfies the rules for Simple Harmonic Motion (S.H.M.) – that is, show that $a = -C x$, where C is some constant you will find.

Draggin' Mah Pick 'Em Up Truck (25,000 points)



3.) A rear wheel drive pickup truck ($m = 1808 \text{ kg}$) goes from zero to 60 mph ($v_f = 26.8 \text{ m/s}$) in ten seconds flat ($\Delta t = 10.00 \text{ s}$). (a) Each tire has a radius of 0.450 m. What are ω_0 and ω_f ?



(b) Find α .

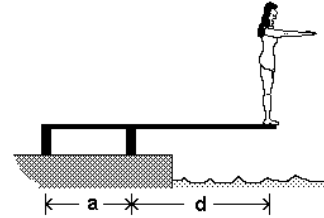
(c) Each tire has a mass of 17.0 kg, and the wheels that the tires are mounted on have a mass of 10.0 kg. Let the wheels be considered solid disks of radius $r_1 = 0.300 \text{ m}$, and the tires to be thin hoops of radius $r_2 = 0.450 \text{ m}$. Find the moment of inertia, I , of the two mounted tires on the rear axle. *Neglect the mass of the axle itself.*

(d) What is the torque, τ_{spin} , needed to accelerate the rear wheels?

(e) The force that moves the truck forward comes from friction as the wheel turns on the ground. Since this friction force is applied at a distance r_2 from the axle, the tires must be supplying this force as a torque. Find this torque, τ_{forward} . Why don't τ_{spin} and τ_{forward} agree? What is the actual torque that the engine has to supply?

Dive! Dive! Dive! (25,000 points)

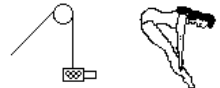
4.) (a) Wei Lin Shi of the People's Republic of China, $m = 45.0 \text{ kg}$, is standing at the end of 3.00 m long diving springboard (mass = 20.0 kg), contemplating her next jump. The board is supported at the left end by two struts, 1.20 m apart. Draw the Free Body Diagram and Free Rotation Diagram of the diving board. Call the support force on the left F_1 and the support toward the middle F_2 . Assume that the diving board is completely uniform.



What are the vector support forces, (b) F_1 and (c) F_2 ?



(d) One of the cooler technologies at the 1996 Olympics was NBC's "dive cam", where a camera (5.00 kg) was moved on a cable to follow the diver. If the cable is a composite fiber ($Y = 10.1 \times 10^6 \text{ N/m}^2$, with a radius of 0.00700 m), what is the strain on the cable while the camera is at rest? *Ignore the pulley.*



(e) If the length of cable above the camera is 1.125 meters, then how far is the cable stretched?

“Toto, I don’t think we’re in Kansas, anymore...” (25,000 points)

5.) In the movie *The Wizard of Oz*, Dorothy’s house is lifted up and carried off to Oz by a tornado. The house has a mass, $m = 8540$ kg, and a moment of inertia, $I = 285,000$ N·m². It is whirling around once every two seconds, or $\omega = 3.14$ rad/s. Find (a) L and (b) K for the rotational motion.

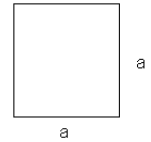
(c) What is the total energy of the house as it is spinning at $\omega = 3.14$ rad/s, has an altitude of 3000. m and is falling at 11.5 m/s?

(d) The Wicked Witch of the East ($m = 135.5$ kg) is hovering at rest with her broomstick when the house, which is no longer spinning but still falling at 11.5 m/s, collides inelastically with her. What is the final speed of the house+witch?

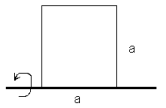
(e) The collision takes place over 0.0103 seconds. Use *impulse* to find the force on the Wicked Witch of the East from the collision. *If you didn’t get an answer to (d), use v_f for the witch as 11.5 m/s.*

Odds and Ends (25,000 points)

6.) ☆(a) A plate of mass $m = 5.00$ kg has sides $a = 0.480$ m. Find the center of mass coordinates x_{cm} and y_{cm} by integrating $x_{cm} = \frac{1}{M} \int x dm$.



☆(b) A plate of mass $m = 5.00$ kg has dimensions $a = 0.480$ m. Find the moment of inertia I of the plate about an axis along the bottom edge as shown, by integrating $I = \int r^2 dm$.

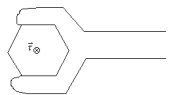


☆(c) An solid disk of mass 71.3 kg and radius 1.21 m has a motion that follows the following equation. Find the angular acceleration, α , at time $t = 1.00$ sec.

$$\theta(t) = 4.00 \text{ rad} - 4.00 \text{ rad/s} t + 4.00 \text{ rad/s}^2 t^2 - 4.00 \text{ rad/s}^3 t^3 + 4.00 \text{ rad/s}^7 t^7 - 4.00 \text{ rad/s}^8 t^8$$

(d) Find the torque vector $\vec{\tau}$ at $t = 1.00$ sec. *Use Right Hand Rule to explain your answer.*

☆(e) A torque $\vec{\tau}$ to tighten a bolt consists of a force being applied at a distance from the axis of rotation. As the bolt gets tighter, it gets harder and harder to turn the bolt, so the torque as a function of angle is given by $\tau = C \theta^2$, where C is some constant with appropriate units. If the total work done by applying this torque through two complete revolutions is 1500. J, then find C .



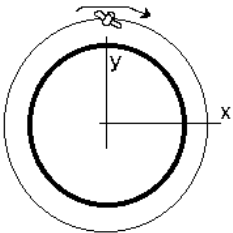
Mars (25,000 points)

7.) The planet Mars has a radius of 3398 km and a mass of 6.57×10^{23} kg. (a) An astronaut in a spacesuit has a weight of 981 N on the surface of the Earth. What would their weight be on the surface of Mars?

(b) The Mars Observer satellite ($m = 227$ kg) is in a circular orbit 111 km above the surface of Mars. Calculate the acceleration due to gravity at this altitude.

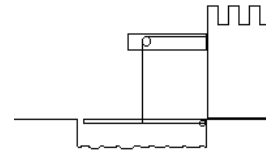
What is the orbital speed of the satellite in (c) m/s and (d) the angular speed in rad/s? *If you didn't get an answer to (b), use $a_c = g/4 = 2.45$ m/s².*

(e) The general solution to the Simple Harmonic Oscillator problem is $x(t) = A \sin(\omega t) + B \cos(\omega t)$. Consider our satellite going around Mars in the x - y plane. Find the value of the constants A and B which describe $x(t)$, for when the satellite is at $x = 0$ and $t = 0$ as shown.

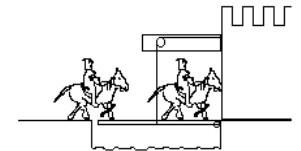


From the Days of Chivalry and Knights Errant (25,000 points)

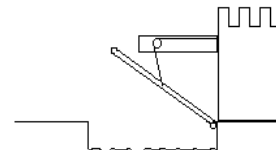
8.) A drawbridge, 8.00 m long and with a weight of 2350 N, is lowered over a moat. It is held up by a hinge at the right and a cable that attaches to the middle of the drawbridge. There is no support on the left. Find (a) the tension in the cable, T_1 , and (b) the force, F_1 , supplied by the hinge.



(c) A bunch of knights in armor and their horses come clomping across the bridge. Explain (briefly!!!) what happens to T_1 and F_1 as the loading on the bridge continues.



(d) Set up *but do not solve* the equations for where the drawbridge is raised at a 40° angle, where the cable is 10° off from vertical.



(e) The 4.00 meter long cable ($Y_m = 13.5 \times 10^{10}$ N/m²) is stretched by 4.00×10^{-3} m by the tension force found in part (a). What is the diameter of the cable? *If you didn't get the answer in (a), use $T_1 = \text{weight of the drawbridge}$.*