FINAL - Preview

$W_{Full} = 0$
$W_{3/4} \neq 0$

1) The total work done by the Sun on a planet in an elliptical orbit for <u>three-quarters</u> of a complete rev is zero?

2) If you continued to study physics for a few more years, you would learn the underlying reason that energy is conserved. It turns out that in fancy equations, energy and time always go together. Energy is conserved as long as your system is time-invariant; in other words, laws would be the same if you ran time backwards. This is a freebie, and is true!

3) Likewise, you would learn the underlying reason that momentum is conserved. It turns out that momentum and "direction" always go together. Momentum is conserved as long as space is isotropic; meaning that the very fabric of space is not prejudiced and is the same in every direction. This is another "true" freebie!

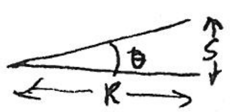
4) When a car rounds a corner while continuing to speed up, it has zero total acceleration because the radial and tangential accelerations cancel.

a_{radial} and $a_{tang.}$ are in different directions – so they can <u>never</u> cancel.

5) An object will fall over if:

otherwise a Torque exists as gravity pulls about the pivot pt.

a) its center of gravity is too high.
b) its center of gravity is too low.
c) its center of gravity is not over an area of support.
d) there is a sideways force on the object, below its center of gravity.



6) An eagle's eye can just barely resolve objects that subtend an angle of 0.0003 rads. Flying 100 meters above the ground, what is the smallest prey it can see?

$\theta = \frac{S}{R} = \frac{prey}{100\,m} = .0003$

a) 3 cm. $= .03\,m$ b) 0.03 cm. c) 18.8 cm. d) 0.19 cm.

7) If a football is kicked so that the force acts through the ball's center of gravity, the ball will:

the foot does not create a Torque about the ball's COM – so no rotation results

a) tumble end over end in the air.
b) not even get off of the ground.
c) spin about its long axis in the air.
d) move without tumbling or spinning.

8) Choosing a pivot point about which to take torques means that the object will rotate about that point.

FALSE. Choosing a pt. just allows you to begin an analysis. It does not mean the object must rotate (at all).

yes - b/c lever arm distance = 0.

9) Choosing your pivot point to be at exactly where an external force is being applied will eliminate that force from the torque eqns?

yes - linearly

10) It is possible for a body to accelerate even with a net torque of zero.

the broth's inertia allows it to NOT rotate -- so no energy is wasted rotating it --- it wins.

11) Two un-opened cans of soup have the same mass and size. One is broth---basically water. The other is very thick inside and will not pour out if the can is opened. The cans are placed on their sides so that they will roll down an incline. If the cans both start from rest and race down the incline the same distance, the broth will win.

The solid soup is "connected" to the can and must rotate. Energy is then used both to move and rotate -- it rolls more slowly.

$\frac{G m M}{r^2} = \frac{m v^2}{r}$

so small r = big V

12) Each planet has a different orbital speed around the sun. Rank the speeds of the first three planets in order of fastest to slowest. Spatially, the order is (M)ercury closest, then (V)enus, then the Earth (E) farthest.

a) E, M, V b) E, V, M c) M, V, E d) V, E, M e) M, E, V

True ; $V = r\omega$ = constant. If ω = constant $\alpha = \frac{\Delta\omega}{\Delta t}$ is 0

13) When a car rounds a corner while on cruise control at constant speed, it has zero angular acceleration.

14) A straight line about which rotational motion takes place is called an axis. — true - just a definition

15) For which of the following objects is the center of mass located outside of the object.

a) milk inside of a very heavy lead crystal glass.
b) a cookie with irregular chunks of nuts and chocolate chips.
c) a donut.
d) an apple.

if $F_{net} = 0$
$a = 0$
$v = const$
$mv = p = const$

16) In order for angular momentum to be conserved, the total external torque must be zero.

$\Rightarrow$ likewise, if $\tau_{net} = 0$, $\alpha = 0$, ω = constant, $I\omega = L$ = constant

17) A spinning planet can maintain its angular momentum, L, but only if no (NET) outside torques act. - see #16.

18) The Earth's angular momentum is not only fixed in magnitude, but in direction. That direction is inclined from the plane of its orbit at about 23 degrees. As the Earth moves around the sun, the Earth's L never moves. This is why we have seasons! TRUE

any displacement will cause it to "fall"

19) If an object is in unstable equilibrium, any displacement will:
a) raise its center of gravity.
b) lower its center of gravity.
c) neither of the above.
d) increase its mass.

larger lever arm

20) Chimps have about one-third of the muscle mass of adult human males, but are twice as strong in some movements. What could account for this?
a) adrenaline.
b) the attachment is closer to the bone's pivot.
c) the attachment is further from the bone's pivot.
d) less friction in the Chimp's movements.

More than twice

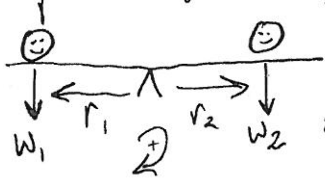
21) The power of one large hurricane is about 2 x 10^{13} Joules per second. T This is twice as large as the world energy consumption rate for coal, natural gas, and petroleum combined!

22) Why are doorknobs placed at the edges of doors
a) It looks better.
b) To increase the force on the door.
c) To help give more momentum.
d) To increase the lever arm.

False: a net outside Torque is required to give it an angular acceleration.

23) A spinning wheel will maintain an angular acceleration as long as no outside torques act on the wheel.

24) Two children are on a seesaw. One's mass is 30 kg, and is located 2.5 m from the fulcrum. The other's mass is 25 kg. Where must this child be to balance?



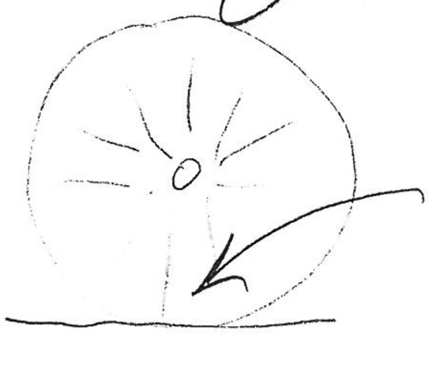
a) 2.5 m
b) 2.08 m.
c) 3.0 m
d) 2.74 m.

$\sum \tau = 0 = W_2 r_2 - W_1 r_1$

Something has to be $\neq 0$

25) Consider an object that is NOT in static equilibrium. Is it possible for the net force to be zero on that object? - yes, but only if $\sum \tau \neq 0$.

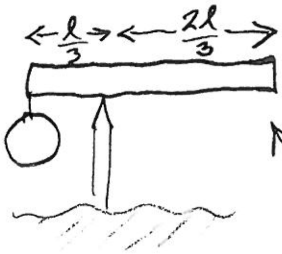
26) Photographs of Olympic bike racers in action often show the spokes of a given wheel in focus at one place and out of focus at other places. Your friend says, "You've taken physics, explain this please".
a) The spokes on the top of the wheel are in focus, while those at the bottom, or toward the ground, are out of focus.
b) No, its really just the opposite of the above answer.



Wheel here is touching the ground and therefore not moving for an instant -- Not blurry.

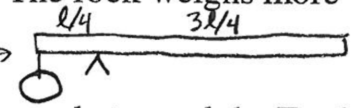
More τ created by your W when at top

27) A ladder is leaning against a wall ready for use. From the physics, is the ladder more likely to slip on the ground when you are at the bottom or the top of the ladder?
a) top b) bottom



28) Examine the figure shown, which is balancing nicely. Compare the mass of the stick to that of the rock. Note: the rock is not touching the ground.
a) The stick weighs more b) The rock weighs more c) same

Sum Torques = 0 ; FOR→



→ masses = same

larger r creates larger I creates smaller ω.

29) If there were a great migration of people toward the Earth's equator, how would this effect the Earth's rotation?

30) Why do tightrope walkers carry long, narrow poles?
b) The pole's weight increases the total N force on the rope, which makes friction larger and slipping less likely.
c) The rotational inertia of the pole is very large compared to its weight.
d) The rotational inertia of the pole is very small compared to its weight.

31) Why do animals that need to run fast have slender lower legs and meaty upper legs?
a) The rotational inertia of the leg is very large that way.
b) The rotational inertia of the leg is very small that way.

smaller r, I larger ω

32) Suppose you are on the edge of a large rotating wheel—like a merry-go-round. What happens if, instead of walking around either cw (clockwise) or ccw, you walk directly toward the center?

33) An empty soup can, with its top and bottom removed, begins to roll from rest without slipping down an incline with a height h = 1.5 meters. The can is thus like a hollow pipe, with all of its mass at a radius r = 3.8 centimeters. At the bottom of the loop its translational speed is?
a) 9.8 m/s
b) 4.8 m/s
c) 3.8 m/s
d) 4.4 m/s
e) 6.3 m/s

Conservation of Energy

$$mgh_i + \frac{1}{2}mv_i^2 + \frac{1}{2}I\omega_i^2 = mgh_f + \frac{1}{2}mv_f^2 + \frac{1}{2}I\omega_f^2$$

$h_i = 1.5\,m$, $h_f = 0$. $I = mr^2$, $\omega_f = v_f/r$, $v_i = \omega_i = 0$

$$\cancel{m}gh_i = \frac{1}{2}\cancel{m}v_f^2 + \frac{1}{2}(\cancel{m}\cancel{r^2})\frac{v_f^2}{\cancel{r^2}} = v_f^2$$

$$v_f = \sqrt{gh} = 3.83\ m/s$$

Use $V_{tang.} = r\omega$

$d = 12m$

$r = 6m$

34) You wish to design helicopter blades so that no part of the blade travels faster than the speed of sound. If the blades are such that the total diameter is 12 meters, what is the largest possible angular velocity? Use 330 m/s for the speed of sound.

a) 55 rads/sec
b) all of the above
c) 55 revs/sec
d) none of the above
e) 55 rpm

$$\frac{330 \frac{m}{s}}{6m} = \omega_{MAX}$$

35) The forces that hold a rigid body together are finite in strength. A rapidly rotating body, for instance, requires very large forces to hold it together. If such a rotating body, such as a turbine blade, were to suffer cracks and ultimately fail, a deadly situation can result. Consider a flywheel with a radius of 50 centimeters. If it rotates at 1000 rads per second, what is the force per kilogram necessary to hold the particles together at the rim ?

a) 10^3 N
b) 5×10^2 N
c) 5×10^5 N
d) 10^6 N
e) 5×10^4 N

$$F = \frac{mv^2}{r} = mr\omega^2 \quad \text{because } v = r\omega$$

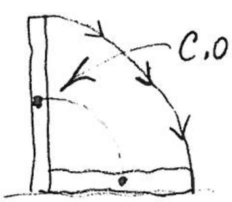
$$\frac{F}{m} = \frac{\text{force}}{Kg} = r\omega^2 = (.5m)\left(1000 \frac{\text{rads}}{\text{sec}}\right)^2$$

$= \frac{1}{2}$ million

Conservation of Energy!

$mgh \Rightarrow \frac{1}{2} I \omega^2$

36) Consider the installation of a telephone pole. A 10 meter long pole was set to vertical and about to be placed in its hole when the workers accidentally let it fall over. If the place where the pole touches the ground has sufficient friction so that the pole pivots about that point as it falls, then no displacement occurs, and therefore, no work is done by either the normal or friction forces. What is the speed in meters per second of the very tip of the pole just before it hits the level ground? Consider the pole to be a long and skinny uniform object. Hint: There is no COM motion here, it is all rotation.



a) 9.8 m/s
b) 13 m/s
c) 14 m/s
d) 17 m/s
e) 28 m/s

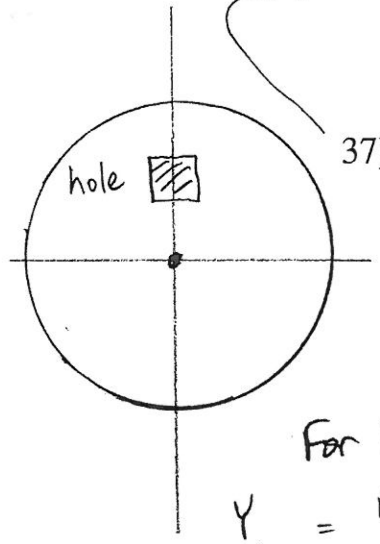
C.O.M begins at h = 5m and falls to h = 0.

$$I_{rod} \text{ (about end)} = \frac{1}{3} m\ell^2$$

$$\cancel{m}g(5m) = \frac{1}{2}\left(\frac{1}{3}\cancel{m}\ell^2\right)\omega^2$$

so $\omega^2 = \frac{6g(5m)}{(10m)^2}$, or $\omega = 1.714$, Finally, $V_{tip} = r_{tip}\omega = \underline{17.14 \ m/s}$

$$\frac{M_{circle}}{\text{size circle}} = \frac{M_{hole}}{\text{size hole}} \Rightarrow M_{hole} = \frac{200}{\pi r^2}(.25)^2 = 3.98\text{ kg}$$



37) Find the center of mass of the following system; as measured from an origin at the center of the large circle. A thin and uniform steel plate is cut into the shape of a circle 100 centimeters in radius. It then has a mass of 200 Kg. A square hole is then cut out as shown, centered on the positive y-axis. The center of the hole is 50 centimeters from the origin, and is 25 centimeters on a side. First, the $X_{com} = 0$ via symmetry.

For hole, use "negative" mass and insert into the com equation: 2 objects (circle, hole)

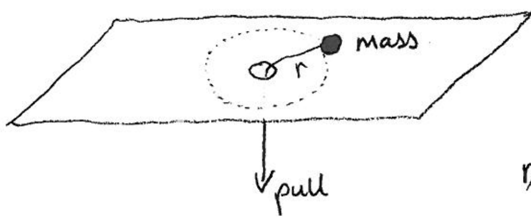
$$Y_{com} = \frac{M_{circle}\, y_{com\,circle} + M_{hole}\, Y_{com\,hole}}{M_{circle} + M_{hole}} = \frac{200(0) + (-3.98\text{ kg})(50\text{ cm})}{200 - 3.98} = -1.015\text{ cm}$$

so $(X, Y)_{com} = (0, -1.015\text{ cm})$

38) A mass m is attached to a string, and set into circular motion as shown on a flat, level, frictionless tabletop. The initial speed of the mass around the circle is 2.4 m/s, and the initial radius of the circular motion is 0.8 m. If the string is pulled by the hand so that the radius of the circle is reduced to 0.48 m , what is the new speed?

Conservation of L b/c $\Sigma\tau = 0$. (Tension creates zero torque!)

a) 2.4 m/s
b) 1.44 m/s
c) 0.864 m/s
d) 6.67 m/s
e) 4 m/s



$$\boxed{L_i = L_f}$$

$$I_i\omega_i = I_f\omega_f$$

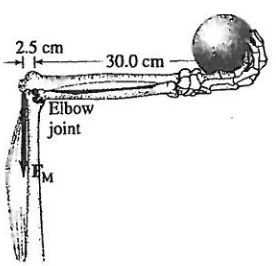
$$\cancel{m} r_i^2 \omega_i = \cancel{m} r_f^2 \omega_f$$

using $\omega = \frac{V_{tang}}{r}$, we have $r_i V_i = r_f V_f$

$(.8\text{m})(2.4\frac{\text{m}}{\text{s}}) = (.48\text{m}) V_f \Rightarrow = 4\text{ m/s}$

Assume uniform "a" and "α"

39) The forearm shown puts a large force on the ball, accelerating it from rest to a speed of 10 m/s in the short time of 0.35 seconds. The ball's mass is 1.5 kg., and the forearm, which rotates like a uniform rod about the pivot, has a mass of 3.7 kg. What is the (uniform) force required from the triceps muscle?



a) 1710 N
b) 5940 N
c) 937 N
d) 23.4 N
e) 78 N

$$V_f = \cancel{V_i}^{\,0} + at \Rightarrow a = \frac{V_f}{t} = \frac{10\text{ m/s}}{.35\text{ s}} = 28.57\text{ m/s}^2$$

$$\alpha = \frac{a}{R} = \frac{28.57\text{ m/s}^2}{.3\text{ m}} = 95.23\text{ rads/s}^2$$

$$I = m_b \ell_b^2 + \frac{1}{3} m_{arm} \ell^2 = (1.5\text{ kg})(.3\text{m})^2 + \frac{1}{3}(3.7\text{kg})(.3\text{m})^2$$

$$= .246\text{ kg-m}^2$$

$$\Sigma\tau = R \times F = I\alpha \Rightarrow F_{muscle} = \frac{I\alpha}{R} = \frac{(.246)(95.23)}{.025}$$

$$\doteq 937\text{ N}$$

$D = Vt$ $a_{circle} = V^2/r$ (inwards) $Y = Y_o + V_o t + (1/2)at^2$ $V(avg) = (1/2)(V_i + V_f)$

$V_f = V_i + at$ $V_f^2 = V_i^2 + 2a(\Delta x)$ $\sum \mathbf{F} = m\mathbf{a}$ $\mathbf{F} = \Delta \mathbf{p}/\Delta \mathbf{t}$ $KE = (1/2)mv^2$

$A = \pi R^2$ $V = (4/3)\pi R^3$ $C = 2\pi R$ sin = opp/hyp cos = adj/hyp

$Range = V_i^2 \sin(2\phi)/g$ $F = \frac{GmM}{R^2}$ $G = 6.67 \times 10^{-11}$ $g = 9.8$ $W = mg$

$Friction = (mu)_k N$ $Friction \leq (mu)_s N$ $PE_{spring} = (1/2)k\,x^2$ $F_{spring} = -k\Delta x$

$PE_{grav} = mgh$ ***or*** $PE_{grav} = -\frac{GMm}{R}$ Power = work/time $\sum \mathbf{F} \bullet$ **displ.** $= \Delta KE$

work = F • displ. = Fd cos(theta) momentum = $\mathbf{p} = m\mathbf{v}$ impulse = $\mathbf{F}\Delta t = \Delta \mathbf{p}$

Radius(Sun) = 6.96×10^8 m Radius(Earth) = 6.36×10^6 m R(Moon) = 1.74×10^6 m

masses: Sun = 1.99×10^{30} kg Moon = 7.35×10^{22} kg Earth = 5.97×10^{24} kg

distances: Earth-Moon = 3.85×10^8 m Sun-Earth = 1.5×10^{11} m 1 mile ≈ 1609 m

$x \rightarrow \theta$ $\mathbf{v} \rightarrow \boldsymbol{\omega}$ $\mathbf{a} \rightarrow \boldsymbol{\alpha}$ $\mathbf{F} \rightarrow$ Torque mass $\rightarrow I$ $\mathbf{p} = m\mathbf{v} \rightarrow \mathbf{L} = I\boldsymbol{\omega}$

$x = R\theta$ $\mathbf{v} = R\boldsymbol{\omega}$ $\mathbf{a} = R\boldsymbol{\alpha}$ Torque = $\mathbf{R} \times \mathbf{F}$ = $RF\sin(\theta) = I\boldsymbol{\alpha}$

$\Delta\theta = {}^{\text{arc length}}/R$ $I = \Sigma\, mr^2$ $I_{ball} = (2/5)mr^2$ $I_{hoop} = (1)mr^2$ $I_{disk} = (1/2)mr^2$

λ = charge or mass/length σ = charge or mass/area ρ = charge or mass/volume