Announcements

1. **Exam 3 starts Friday!**
   a. Available in Testing Center from Friday, Nov 9 (opening time), up to Monday, Nov 12 at 4:00 pm.
      i. Late fee if you start your exam after 4 pm
   b. Covers Ch. 6-8 (up through HW 16)
   c. Sample Exam 3 is posted on the website and Sample Exam 3 Solutions also.
   d. Exam 3 formulas posted on website: which ones you need to memorize, and which ones will be given
      i. Also in today's notes
   e. Difficulty level: in between exam 1 and exam 2 (think Goldilocks & the Three Bears ☺)
   f. There's still a **3 hour time limit**
   g. Remember to write out legible solutions on your exam
   h. The usual answering system:
      i. [1?] = pick a multiple choice answer
      ii. [1S] = get a numerical answer; bubble in the **S**econd digit.
2. Late submissions for HWs 10 through 16 are due Friday evening

Exam 3 formulas

To be given on exam

Continued from exams 1 & 2

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New for exam 3

arc length: $s = r\theta$

tangential $v = r\omega$

$a_c = v^2/r$

gravity: $F = \frac{GMm}{r^2}$, $PE_g = -\frac{GMm}{r}$

$G = 6.67 \times 10^{-11}$ N·m^2/kg^2

$R_{earth} = 6.38 \times 10^6$ m

$M_{earth} = 5.98 \times 10^{24}$ kg

$M_{sun} = 1.99 \times 10^{30}$ kg

$I_{sphere} = (2/5)\ MR^2$

$I_{hoop} = MR^2$

$I_{disk} = ½\ MR^2$

$I_{rod\ (center)} = (1/12)\ ML^2$

$I_{rod\ (end)} = (1/3)\ ML^2$

To be memorized

Continued from exams 1 & 2

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New for exam 3

Definition of momentum: $p = mv$

Conservation of momentum: $\sum p_{before} = \sum p_{after}$ (if no outside force)

Angular kinematics: replace x with θ, v with ω, and a with α in all the kinematics formulas

Quick derivation of satellite velocity: $\frac{GMm}{r^2} = m\frac{v^2}{r}$

Period: $T = 2\pi r/v$

Definition of torque: $\tau = r_\perp F = rF_\perp = rF\sin\theta$

Moment of inertia for point mass: $I = mr^2$

$I_{tot} = I_1 + I_2 + \ldots$

Angular KE: $KE = ½\ I\ \omega^2$

Newton's 2nd Law for torques: $\sum \tau = I\alpha$

Definition of angular momentum: $L = r_\perp p = rp_\perp = rp\sin\theta$, also $L = I\omega$

Exam 3 - Review of important concepts

1. Momentum
   a. Definition
   b. Conservation Law
   c. Collision problems
      i. 1D
      ii. 2D – think of momentum components in each direction
   d. Elastic vs. Inelastic
   e. Combination problems (e.g. bullet into block of wood)
   f. Center of mass motion

2. Rotational motion
   a. Angular quantities: θ, ω, α
      i. How they relate to "regular" quantities
      ii. Radians – 2π radians in a circle
   b. Kinematic equations
   c. Connection between linear and rotational motion: ω = v/r, etc.

3. Centripetal acceleration, $a_c = v^2/r$
   a. Difference between centripetal and tangential
   b. Newton's Law of Gravity and orbits

i. Period vs. velocity vs. ω
ii. Potential energy

c. "Roller coaster" problems
i. Normal force = 0 when you "fly out of your seat"

4. Torque
a. Definition
i. "lever arm" concept, $r_\perp$
b. Equilibrium problems: $\Sigma F = 0$, $\Sigma\tau = 0$
c. Moment of inertia
i. Point mass: $I = mr^2$ memorized
ii. I for other situations will be given
d. Newton's 2nd Law for rotations: $\Sigma\tau = I\alpha$
e. Torques and rotation
i. Combining Newton 2 with kinematics

5. Rotational kinetic energy & momentum
a. Definitions
b. Conservation laws
c. The two expressions for L:
$L = r_\perp p$ and $L = I\omega$

HW 11, Problem 3

An 8.29-kg mass moving east at 11.6 m/s on a frictionless horizontal surface collides with a 18.5-kg mass that is initially at rest. After the collision, the first mass moves south at 4.6 m/s. What is (a) the magnitude and (b) the direction of the velocity of the second mass after the collision? (c) What percentage of the initial kinetic energy is lost in the collision?

Answers: 5.59 m/s, 21.6 N of east, 32.4% lost

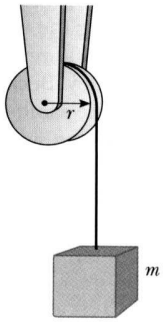
HW 13, Problem 3

A satellite of mass 185 kg is launched from a site on the Earth's Equator into an orbit at 380 km above the surface of the Earth. (a) Assuming a circular orbit, what is the orbital period of this satellite? (b) What is the satellite's speed in orbit? (c) What is the minimum energy necessary to place this satellite in orbit, assuming no air friction? Note: Its initial energy is its potential energy at the surface of the Earth. (Neglect its kinetic energy due to the rotation of the earth about its axis.)

Answers: 92.2 min, 7.68 km/s, 6.11E9 J

HW 15, Problem 4

A light string is wrapped around a solid cylindrical spool of radius 0.565 m and mass 1.79 kg. A 1.04 kg mass is hung from the string, causing the spool to rotate and the string to unwind. Assume that the system starts from rest and no slippage takes place between the string and the spool. By direct application of Newton's second law, determine the time required for the mass to drop 4.19 m.



Answer: 1.26 s

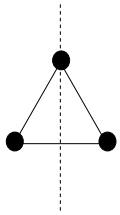
More Sample Exam Problems (answers at end)

Problem 1. A boy is at the stern (back) of a sailboat with a bunch of beanbags. The wind has stopped. If the boy throws the beanbags against the sail with sufficient velocity, he can get the boat to move forward. [1?] _____ 1) True 2) False

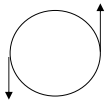
Problem 2. Two snowballs are thrown at each other. One is 2 kg traveling to the right at 3 m/s. The second is 0.5 kg traveling to the left at 8 m/s. After they collide they stick together. Their velocity after they stick is to the [2?] _____ 1) right 2) left at [3S] _____ m/s. In this collision, total kinetic energy was conserved: [4?] _____ 1) True 2) False. If instead they are traveling north and east respectively, the final velocity will be [5S] _____ m/s.

Problem 3. A 0.5 kg ball is tied to a string of length 4m, and the ball is whirled around in a horizontal circle. The tension in the string is 60 N. The speed of the ball as it goes around the circle is [6S] _____ m/s.

Problem 4. Three masses of 2 kg each are arranged in an equilateral triangle of side 6 m. Treat them as point masses and find the moment of inertia of this system about the vertical axis as shown. [7S] _____kg m^2.

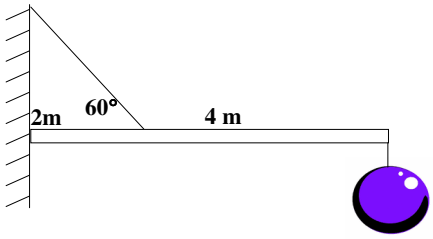


Problem 5. A satellite has a moment of inertia of 900 kg m^2 about an axis through its center. It is initially not spinning, **but rockets 2m from the edge provide 40 N of force each** to rotate the satellite about this axis. After a time of 20 seconds, the rockets turn off. At this time, the angular velocity of the satellite is [8S] _____ rad/s.



Problem 6. A small asteroid of mass 800 kg gets trapped in orbit around the planet Saturn, which has mass 5.68×10^{26} kg. The radius of orbit is 3×10^8 m from the center of Saturn. The force of gravity between the asteroid and Saturn is [9S]_____ N. The acceleration of the asteroid is [10S]_____ m/s^2.

Problem 7. A 6 m beam weighs 800 N. The weight of the ball is 1200N. The tension in the angled supporting cable is [11S]_____ N.



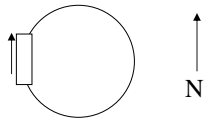
Problem 8. You go around a curve in your car at constant speed. The tangential acceleration of the car is zero: [12?] _____ 1) true 2) false. The direction of the net force on the car is outward from the circle: [13?] _____ 1) true 2) false.

Problem 9. A solid cylinder of mass 30 kg and radius 80 cm is rolling on the floor without slipping, and has 500 J of *total* kinetic energy. The moment of inertia of the cylinder about its axis is [14S] _____ kg m^2. The speed of the cylinder is [15S] _____ m/s. The cylinder will roll up an incline to a height of [16S] _____ m.

Problem 10. Two children sit on a teeter totter, which has a pivot at its center. The boy is mass 30 kg is 70 cm to the left of the center. The girl has mass 50 kg. How far <u>from the center</u>, on the right side, should the girl sit to balance the teeter-totter? [17S]_____ cm.

Problem 11. A large solid steel sphere and a small steel hoop are rolled down an inclined plane. The hoop will get to the bottom first. [18?]_____1) true 2) false

Problem 12. A car of mass 500 kg, moves around a curve of radius 30 m at a speed of 7 m/s, as shown. The road's turning force on the car is [19S] _____ N. If the car is slowing down, the direction of its total acceleration is to the [20?]_____ 1) north 2) south 3) east 4) west 5) northwest 6) northeast 7) southwest 8) southeast



(Note: actual exam will be longer—more like 30 answer blanks, not 20)

Answers to "More Sample Exam Problems"

→ <u>Not guaranteed</u> (I didn't double-check my work) Bonus points possible for those who find errors; send me an email (but don't claim an error unless you are <u>really sure</u>, and are able to tell me the right answer).

1) 2 (false)
2) 1 (right)
3) 0 (0.80 m/s)
4) 2 (false)
5) 8 (2.88 m/s)
6) 1 (21.9 m/s)
7) 6 (36 kg m^2)
8) 5 (3.56 rad/s)
9) 3 (337 N)
10) 2 (0.421 m/s^2)
11) 1 (11085 N)
12) 1 (true)
13) 2 (false)
14) 6 (9.6 kg m^2)
15) 7 (4.71 m/s)
16) 7 (1.70 m)
17) 2 (42 cm)
18) 2 (false)
19) 1 (817 N)
20) 8 (southeast)