This exam consists of:

- 15 multiple choice concept questions – 1 pt each
- 12 short problems – show your work – 3 pts each
- 7 long problems – show your work – 7 pts each

Instructions:

- You will have 2 hours to complete this exam
- Do not open the test until you are told to do so.
- Mass moment of inertia equations are given on the back of this instruction sheet.
- Write your final answer in the box provided
- If you finish with less than 5 minutes remaining, please stay seated until the exam is over.
- Stop work immediately when time is over; pass exams to the aisle; stay seated until all exams are collected. Working after time is over is an automatic 10 point deduction.

Guidelines:

- Assume 3 significant figures for all given numbers unless otherwise stated
- Show all of your work – no work, no credit
- Include units for all answers
- Include directions for all vectors
**Mass Moment of Inertia**

*Also called Moment of Inertia, Angular Mass*

<table>
<thead>
<tr>
<th>Thin hoop or ring of radius R &amp; mass M:</th>
<th>Thick ring of inner radius R1, outer radius R2, and mass M:</th>
<th>Solid cylinder or disc of radius R and mass M:</th>
<th>Flat plate with sides of length A and B and mass M:</th>
</tr>
</thead>
<tbody>
<tr>
<td>$M r^2$</td>
<td>$M \left( r_1^2 + r_2^2 \right) / 2$</td>
<td>$M r^2 / 2$</td>
<td>$M \left( A^2 + B^2 \right) / 12$</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Solid sphere of radius R and mass M:</th>
<th>Thin-walled hollow sphere of radius R &amp; mass M:</th>
<th>Slender rod of length L and mass M, spinning around center:</th>
<th>Slender rod of length L and mass M, spinning around end:</th>
</tr>
</thead>
<tbody>
<tr>
<td>$(2/5)M r^2$</td>
<td>$(2/3)M r^2$</td>
<td>$M L^2 / 12$</td>
<td>$M L^2 / 3$</td>
</tr>
</tbody>
</table>
15 multiple choice problems – circle the correct answer -- 1 pt each

1. You want to make a scale model of a coffee can that is 4x smaller in every dimension. The volume of the actual can is 64 in$^3$. What is the volume of the scale model?
   A. 1 in$^3$
   B. 8 in$^3$
   C. 16 in$^3$
   D. 32 in$^3$

2. If you have three vectors where $|\vec{A}| = 3$  $|\vec{B}| = 4$  $|\vec{C}| = 5$
   Which is not a valid magnitude for $|\vec{A} + \vec{B} + \vec{C}|$?
   A. 0
   B. 5
   C. 12
   D. 15

3. An object is moving in a straight line and has an acceleration of -3 ft/s$^2$ and a velocity of -3 ft/s. What is the object doing?
   A. Speeding up
   B. Slowing down
   C. Changing direction
   D. Standing still

4. A 5 lb, 2 inch diameter solid sphere and a 10 lb, 3 inch diameter hollow sphere race down an inclined track. Which one wins?
   A. The small solid sphere
   B. The large hollow sphere
   C. They finish at the same time

5. An object is moving at a constant speed of 3 ft/s and has an acceleration of 3 ft/s$^2$. What is the object doing?
   A. Speeding up
   B. Slowing down
   C. Changing direction
   D. Standing still

6. A 10 lb box is sitting on a horizontal surface. For this combination, $\mu_k=0.2$ and $\mu_s=0.3$. You start pushing on the box with a vertical force 10 lb. What is the magnitude of the friction force?
   A. 0
   B. 2 lb
   C. 3 lb
   D. 4 lb
   E. 6 lb
   F. 10 lb

7. A car is rolling along a horizontal track with an initial velocity $v_0$ and slows to a stop in $t$ seconds while traveling a distance $d$. Which is not a valid way of calculating the average force $F$ that is causing the car to slow down?
   A. $F = m(v_0/t)$
   B. $F = (\frac{1}{2}mv_0^2)/d$
   C. $F = \mu_k N$

8. The value of $(\hat{j} \times \hat{i})$ is:
   A. 0
   B. 1
   C. -1
   D. $\hat{k}$
   E. $-\hat{k}$

9. What does the area under a force-time graph represent?
   A. Work
   B. Change in momentum
   C. Change in velocity
   D. Change in kinetic energy
10. You are given a value with units of ft-lb/hr. What does this value represent?
   A. Power
   B. Efficiency
   C. Momentum
   D. Impulse
   E. Energy

11. What is the y velocity of the top disc after the collision shown in the diagram below?
   A. 0 m/s
   B. +1.5 m/s
   C. +2.5 m/s
   D. +3 m/s
   E. +5 m/s

12. A tractor is accelerating at 4 ft/s² while pulling a trailer. The coupling force on the tractor is 600 pounds. The coupling force on the trailer is:
   A. < 600 lb
   B. = 600 lb
   C. > 600 lb
   D. cannot determine from given information

13. What two things are equal in magnitude when an object falling straight down reaches its terminal velocity?
   A. Its acceleration and gravity
   B. Its weight and the drag force
   C. The drag force and the normal force
   D. The weight and the normal force

14. A car is going around a circle. What are the signs of the centripetal acceleration components when the car is at point A?
   A. x: + y: +
   B. x: - y: +
   C. x: + y: -
   D. x: - y: -

15. Which FBD=KD best represents Smokey riding a ferris wheel moving at constant angular speed at the position shown?
12 short problems – show your work -- 3 pts each

16. A can is dropped from a height of 4 ft.
   How much time goes by before it hits the ground? (ignore air resistance)
   

17. What is the horizontal impulse on a 10 lb object that starts from rest and is accelerated to a horizontal speed of 22 ft/s?
   

18. A spinning object slows down from 50 rad/sec to 20 rad/sec in 3.0 seconds.
   How many revolutions does it make in this time?
19. A 50 g yardstick supports a 100 g mass at the 2 inch mark and a 250 g mass at the 30 inch mark. At what location on the stick could you support it so that it would be balanced horizontally?

20. A moving sidewalk has a velocity of 7 ft/s to the west relative to the floor. Tyler is on the sidewalk walking east at 2 ft/s relative to the sidewalk. Rachel is running 12 ft/s east on the floor. How fast is Tyler moving with respect to Rachel? Use east as the positive direction.

21. A spring contains 50 J of energy when compressed 0.1 meters. How much force is required to compress it this distance?
22. A 12 HP engine produces a torque of 250 ft-lb when running at 150 rpm. What is the efficiency of the engine? (1 HP = 550 ft-lb/sec)

23. What is the mass moment of inertia about point A for a solid bowling ball attached to a rod of negligible mass?

24. Two gears are connected as shown. Determine the angular frequency of the large gear in rpm and specify its direction as CW or CCW.
25. What are the three general types of collisions?
   Give a valid value for the coefficient of restitution for each one.

   1.

   2.

   3.

26. What are the three cases that control how a friction force is calculated?

   1.

   2.

   3.

27. Summarize Newton’s 3 laws of motion (use one sentence or less for each law)

   1.

   2.

   3.
7 long problems -- show your work -- 7 pts each

28. Using the velocity time graph given below, determine the average velocity over the 60 second period.

29. Andrew flies his helicopter 40 miles due north, then 18 miles 20° east of south, and then 30 miles 10° north of east. Determine the distance and direction he needs to fly to get back to his starting location.
30. Taylor throws a ball in the direction shown. 2.0 seconds later Rachel catches the ball. Determine the height (h) of Rachel’s catch.

31. Tyler is pushing a cart up a ramp as shown. Determine the magnitude of the acceleration and state whether the cart is speeding up or slowing down. Neglect friction and drag.

FBD = KD required
32. A car consists of 4 solid cylindrical wheels (each weighing 0.2 kg and having a 0.05 m radius) and a 0.9 kg body. The car starts from rest at point A and rolls down a track. Assume a constant resistance force of 5 N. What is its speed at point B?

33. Determine the total moment about point A. Give the magnitude of the moment and direction as CW or CCW.
34. Tyler pushes Tayler and Rachel on their sleds as shown. Tyler has a tractive force of 133 N to the left. Rachel’s sled moves freely, but Tayler drags her feet on the ground and creates a friction force of 30 N. Find the magnitude of the coupling force between Rachel and Tayler’s sled.

(2 FBD = KD’s required  HINT: start with an FBD=KD of the whole system)