PHY203 **NAME:**_____
EXAM III **ID#:**_____
Nov 16, 2006 **LECTURE TIME:** 9am 1pm 2pm 3pm (Circle one)

1) Four equal point masses m are located in the positions given on the figure below. The position $\vec{r}_{\rm CM}$ of their center of mass is then:

a) $0.5\,\mathbf{i} - 0.5\,\mathbf{j}$

b) $\mathbf{i} + 0.5\,\mathbf{j}$

c) $0.5\,\mathbf{i} + \mathbf{j}$

d) $0.5\,\mathbf{i} - \mathbf{j}$

e) $0.5\,\mathbf{i} + 0.5\,\mathbf{j}$

2) Three particles with the same mass m move with the following velocities: $\vec{v}_1 = -2\mathbf{i}$ (m/s), $\vec{v}_2 = -4\mathbf{j} + 2\mathbf{k}$ (m/s) and $\vec{v}_3 = -\mathbf{i} + \mathbf{j} - 2\mathbf{k}$ (m/s). The velocity $\vec{v}_{\rm CM}$ of their center of mass is then:

a) $-\mathbf{j} + 2\,\mathbf{k}$ (m/s)

b) $-3\,\mathbf{i} - 3\,\mathbf{j} + 4\,\mathbf{k}$ (m/s)

c) $-3\,\mathbf{i} - 3\,\mathbf{j}$ (m/s)

d) $\mathbf{i} + \mathbf{j} + 4\,\mathbf{k}$ (m/s)

e) $-\mathbf{i} - \mathbf{j}$ (m/s)

3) A 2 kg metallic triangle is thrown with an initial speed of 30 m/s and angular speed of of 4π rad/s at an angle of 60^o with respect to the horizontal. Neglecting friction, what is the magnitude of the acceleration of its center of mass?

a) 4.56 m/s^2

b) 9.81 m/s^2

c) 5.78 m/s^2

d) 7.34 m/s^2

e) 6.21 m/s^2

4) Two identical masses move along a straight line with velocities v_1= 20 m/s and v_2= 10 m/s. If they undergo an elastic collision. what are the velocities u_1 and u_2, respectively, after the collision?

a) u_1= 10 m/s and u_2= 20 m/s

b) u_1= -20 m/s and u_2= -10 m/s

c) u_1= -10 m/s and u_2= 20 m/s

d) u_1= 10 m/s and u_2= 5 m/s

e) u_1= 5 m/s and u_2= 10 m/s

5) A 80 kg man stands still on a 100 kg raft at rest on a quiet lake. If the man starts moving at 4 m/s towards the right, what would happen to the raft? (neglect friction between the raft and the water).

a) It would move towards the left at 4 m/s.

b) It would stay still.

c) It would move towards the left at 3.2 m/s.

d) It would move in the same direction of the man but with less speed.

e) It would move in the same direction of the man but with more speed.

6) A 10 kg meteorite moving with a velocity of $5\,\mathbf{i} - 10\,\mathbf{k}$ (m/s) collides with a 40 kg astronaut moving at a velocity of $\mathbf{i} - \mathbf{j}$ (m/s) in free space. The astronaut catches the rock and they move together with velocity:

a) $5\,\mathbf{i} - 10\,\mathbf{k}$ (m/s)

b) $1.8\,\mathbf{i} - 2\,\mathbf{k}$ (m/s)

c) $4.5\,\mathbf{i} - 0.8\,\mathbf{j}$ (m/s)

d) $5\,\mathbf{i} + 0.8\,\mathbf{j} + 2\,\mathbf{k}$ (m/s)

e) $1.8\,\mathbf{i} - 0.8\,\mathbf{j} - 2\,\mathbf{k}$ (m/s)

7) Given two vectors: $\vec{A} = -2\mathbf{i} - \mathbf{j} + 2\mathbf{k}$ and $\vec{B} = 2\mathbf{i} - \mathbf{k}$. Its cross product $\vec{A} \times \vec{B}$ is:

a) -2**i**+2**j**+**k**

b) **i**-2**j**+2**k**

c) **i**+2**j**+2**k**

d) 2**i**+**j**+2**k**

e) 2**i**+**j**-2**k**

8) A Physics student stands still in the middle of a rotating merry-go-round. If suddenly he/she starts to move towards the rim, the angular velocity of the merry-go-round would:

a) increase.

b) remain the same.

c) decrease.

d) stop.

e) there is not enough information to tell.

9) A solid disk of radius 2 m and mass 4 kg moves initially with an angular velocity $\omega = 20$ rad/s. If the disk stops after 5 s, the magnitude of the torque being applied to the disk is then:

a) 16 N m

b) 20 N m

c) 10 N m

d) 32 N m

e) 5 N m

10) If suddenly our planet underwent a gravitational collapse and its radius decreased 10 times, its angular velocity would change to:

a) 2π rad/day

b) 20π rad/day

c) 200π rad/day

d) 0.2π rad/day

e) 0.02π rad/day

Problems

1) A 2 kg firecracker, initially at rest, explodes in three pieces: a piece of 1 kg moving with velocity $\vec{v}_1 = \mathbf{i} + \mathbf{j} + \mathbf{k}$ (m/s); two pieces of 0.5 kg, one moving with a velocity $\vec{v}_2 = -2\mathbf{j} - 4\mathbf{k}$ (m/s), and the other moving with an **unknown velocity** $\vec{v}_3$.
a) Find the total linear momentum of the firecracker before the explosion.

b) What is the total linear momentum after the explosion? (**give a numerical answer**).

c) Find the value of the unknown velocity $\vec{v}_3$.

d) Find the total kinetic energy after the explosion.

2) Two discs of identical mass $m = 2$ kg and identical radii $R = 3$ m are spinning on frictionless bearings at angular velocities $\omega_1 = 4\ rad/s$ and $\omega_2 = 2\ rad/s$ (see figure). The two disks are brought slowly together. The resulting frictional force between the surfaces eventually brings them to a common angular velocity ω_f.
a) Find the magnitude of the total angular momentum before the discs are brought together.

b) What is the magnitude of the total angular momentum after the discs are brought together? (**give a numerical answer**)

c) Find The value of ω_f when the two discs rotate together.

Crib Sheet

$\vec{r}_{\rm CM} = \dfrac{\sum_k m_k \vec{r}_k}{M}, \quad \vec{v}_{\rm CM} = \dfrac{\sum_k m_k \vec{v}_k}{M},$

Elastic collisions : Approaching speed = Receding speed : $v_1 - v_2 = -(u_1 - u_2)$

$\vec{p} = m\vec{v},$

$K = \dfrac{1}{2}mv^2,$

$K_{\rm Rotation} = \dfrac{1}{2}I\omega^2,$

$\mathbf{i} \times \mathbf{i} = \mathbf{j} \times \mathbf{j} = \mathbf{k} \times \mathbf{k} = 0, \quad \mathbf{i} \times \mathbf{j} = \mathbf{k}, \;\; \mathbf{j} \times \mathbf{k} = \mathbf{i}, \;\; \mathbf{k} \times \mathbf{i} = \mathbf{j},$

$\vec{\tau} = \vec{r} \times \vec{F},$

$\tau = \text{Force} \times \text{lever arm} = r\,F\,\sin\theta,$

$\tau_{\rm net} = I\alpha,$

$\vec{L} = \vec{r} \times \vec{p},$

$L = \text{p} \times \text{lever arm} = r\,p\,\sin\theta,$

$L = I\omega,$

$K = \dfrac{1}{2}I\omega^2 + \dfrac{1}{2}mv_{\rm CM}^2,$

$I_{\rm CM}^{\rm disc} = \dfrac{1}{2}MR^2 \quad I^{\rm particle} = MR^2 \quad I_{\rm CM}^{\rm rod} = \dfrac{1}{12}ML^2, \quad I_{\rm CM}^{\rm sphere} = \dfrac{2}{5}MR^2,$

$I = I_{\rm CM} + Md^2,$

$v_t = \omega r, \quad a_t = \alpha r,$

$\theta(t) = \theta_0 + \omega_0 t + \dfrac{1}{2}\alpha t^2,$

$\omega(t) = \omega_0 + \alpha t,$