**Exam II Details:**

Exam II will take place in rooms HECC-108 on October 12th, 2023 from 7:00pm – 9:00pm. It is a common exam, all sections of PHYS 201 will take the same exam at this given time. Please arrive at least 15 minutes early to get settled; we would like to begin exactly on time. If you have any questions during the exam, you may call over one of the proctors monitoring the exam.

**Chapters to be covered on exam :** 6 – 8

**Items to bring:**

- Pencil and eraser
- Scientific Calculator (up to a Ti-84 is allowed)
- Yourself

**Items *not* to bring:**

- Your own formula sheet (one will be provided on exam)
- Scantron (one will be provided on exam)
- Computerized Calculator (example: Ti-nspire with touchpad keyboard)
- A laptop, tablet, or phone (all computer devices should be kept powered off and left in your bag for the duration of the exam)
- Any other prohibited item

**Concepts to review:**

- Circular Motion
  - Centripetal force
  - Angular Velocity
  - Angular Acceleration
- Satellite Motion
  - Gravitational force
  - Period
- Work & Energy
  - Definition
  - Kinetic Energy
  - Potential Energy
  - Conservation of Energy
  - Non-conservative Forces
- Momentum
  - Definition
  - Conservation of Momentum
  - Collisions
  - Impulse

- Center of Mass

**<u>Practice Questions for the Exam:</u>**

**1) Car A (mass = 4000kg) is traveling due east with speed 15 m/s. Car B (mass = 2000kg) is traveling due North with speed 24 m/s. The two cars collide and stick together. The road is icy and friction from the road can be neglected during the collision. What is the speed of the wreckage immediately after the collision?**

Solution: We know that momentum must be conserved in collisions. Because we are told the cars stick together, this makes it an in-elastic collision and so there is no kinetic energy conservation. The total initial momentum must equal the total final momentum, and so we have:

$$m_1 v_1 + m_2 v_2 = (m_1 + m_2)V$$

Where $m_1$ is the mass of the first car (4000kg), $m_2$ is the mass of the second car (2000kg), $v_1$ is the velocity of the first car (15 m/s), $v_2$ is the velocity of the second car (24 m/s), and V is the final velocity of the wreckage.

Because the initial velocities are perpendicular to each other, it is easy to find the components of V. $V_x$ will equal $v_1$ and $V_y$ will equal $v_2$ simply because the x component of $v_2$ is 0, and the y component of $v_1$ is 0.

$$\frac{m_1 v_1 \hat{x} + m_2 v_2 \hat{y}}{(m_1 + m_2)} = \vec{V}$$

Plugging the numbers…

$$\frac{(4000)(15)}{6000}\hat{x} + \frac{(2000)(24)}{6000}\hat{y} = 10\hat{x} + 8\hat{y} = \vec{V}$$

From here we find the magnitude of V to obtain our final answer (i.e. what was the final speed of the wreckage).

$$\sqrt{10^2 + 8^2} = 12.8$$

**2) Two figure skaters, one weighing 625N and the other 725N, push off against each other on frictionless ice. If the lighter skater travels at 1.74 m/s, how fast will the heavier one travel?**

Solution: There are many ways to solve this problem, but the simplest way is to use conservation of energy & Newton's 3rd law. If the skaters were initially at rest, and then moved by pushing off against each other (over a frictionless surface), their kinetic energies will be equal to each other. Knowing their masses (indirectly from their weight) and one of the skater's velocity, we can then solve for the other skater's velocity.

$$\frac{1}{2}\left(\frac{\omega_1}{g}\right)v_1^2 = \frac{1}{2}\left(\frac{\omega_2}{g}\right)v_2^2$$

Canceling the common terms (such as the ½ and g), and then solving for $v_2$, we get:

$$\sqrt{\frac{w_1 v_1^2}{w_2}} = \sqrt{\frac{625(1.74)^2}{725}} = 1.6 = v_2$$

**3) An artificial satellite is orbiting the earth (M earth = 5.97E+24 kg and radius = 38E+6 m) in a circular orbit. If the orbital speed of the satellite is 4000 m/s, what is the radius of the satellite's orbit (measured from the center of the earth)?**

Solution: Here we use combine two equations given to us. The first is the relationship between linear velocity and the radius & period of rotation of an object in circular motion:

$$v = \frac{2\pi r}{T}$$

The second equation is the period of orbit of a satellite:

$$T = \frac{2\pi r^{3/2}}{\sqrt{GM_e}}$$

If we arrange this second equation, we find that we can substitute in the linear velocity:

$$\frac{T}{2\pi r} = \frac{r^{\frac{1}{2}}}{\sqrt{GM_e}} \Rightarrow \frac{1}{v} = \sqrt{\frac{r}{GM_e}}$$

We are given G from the formula sheet (6.67E-11 N*m$^2$*kg$^{-2}$), and the values of $M_e$ (5.97E+24 kg) and v (4000 m/s) in the problem. We can re-arrange the equation to solve for r, and we get:

$$\frac{GM_e}{v^2} = \frac{(6.67 \times 10^{-11})(5.97 \times 10^{24})}{(4000)^2} \approx 2.5 \times 10^7$$

**4) A wheel with radius 0.5m is rotating at a constant angular speed of 3 rad/s. What is the linear speed of a point on the rim of the wheel?**

Solution: In this question the relationship between angular velocity and linear velocity must be known. From the definition of angular speed, it is the number of radians per second. This is given as:

$$\omega = \frac{2\pi}{T}$$

Where T is the period of rotation (i.e. the amount of time it takes for one full rotation). We see from the formula sheet that the relation for linear velocity has these values in it, giving the relationship & answer:

$$v = \frac{2\pi r}{T} = \omega r = (3)(0.5) = 1.5$$

**Example of formula sheet provided on exam:**

$$a_{rad} = \frac{v^2}{R} \qquad v = \frac{2\pi R}{T}$$

$$F_g = G\frac{m_1 m_2}{r^2} \qquad G = 6.67\times10^{-11}\ \mathrm{N\cdot m^2/kg^2} \qquad T = \frac{2\pi r^{3/2}}{\sqrt{Gm_E}}$$

$$W = F_{\parallel}s = (F\cos\phi)s \qquad W_{total} = K_f - K_i = \Delta K$$

$$U_{grav} = mgy \qquad K = \tfrac{1}{2}mv^2 \qquad U_{el} = \tfrac{1}{2}kx^2$$

$$K_f + U_f = K_i + U_i + W_{other}$$

$$P_{av} = \frac{W}{t} \qquad P = F_{\parallel}v$$

$$\vec{p} = m\vec{v} \qquad \Delta\vec{p} = \vec{F}_{av}(t_f - t_i) = \vec{J}$$

$$x_{cm} = \frac{m_A x_A + m_B x_B + m_C x_C + \ldots}{m_A + m_B + m_C + \ldots} \qquad y_{cm} = \frac{m_A y_A + m_B y_B + m_C y_C + \ldots}{m_A + m_B + m_C + \ldots}$$

$$v_{cm,x} = \frac{m_A v_{A,x} + m_B v_{B,x} + m_C v_{C,x} + \ldots}{m_A + m_B + m_C + \ldots} \qquad v_{cm,y} = \frac{m_A v_{A,y} + m_B v_{B,y} + m_C v_{C,y} + \ldots}{m_A + m_B + m_C + \ldots}$$

$$M\vec{v}_{cm} = \vec{P} \qquad \sum \vec{F}_{ext} = m\vec{a}_{cm}$$