PHYSICS 101: Fundamentals of Physics I – Final Exam Prep Sheet

Exam Date: June 12, 2009 1:00pm

On June 12, at 1pm, we'll have our final exam. As with the first two tests, students with last names from A-M will take their test in Nesbitt 111, and those with last names N-Z will take their test in Nesbitt 125. You will have 2 hours to complete the exam, so you should be sure to be on time. The format will be similar to the written homeworks and exams, with calculations based on the equations discussed in class, and similar in structure and difficulty to previous years' exams. I will **not** reuse problems from previous years. Some questions will involve interpretation as well.

Please note that this exam **will** be comprehensive. You can expect problems based on material throughout the term, not just the stuff covered since the second exam. Moreover, everything up to and including material presented on the last day of class (June 8) is fair game, so make sure you look over the recitation and mastering physics problems.

It is expected that you will bring a calculator for the exam. You may not borrow a calculator from your neighbor during the exam.

A formula sheet, identical to the one attached, will be included with the exam. While the formulas will be given, the meanings of the letters in the formulas will not. In your preparation, you should make sure that you understand all terms used in the formula sheet. Finally, the exam will be comprehensive. It is also strongly recommended that you review the homeworks in preparation for the exam, and that you understand all of the mistakes that you've made previously.

Chapters covered:

Young and Freedman: Chapters 1-10

This exam will be cumulative. You should take a look at the topics for the first and second exam sheet, and so I won't re-list those topics here. In addition, I expect you to know about:

• Elastic and inelastic collisions. You should know the distinction between the two, and be able to solve explicitly for 1d elastic collisions and perfectly inelastic collisions.

• Rotational coordinates. You should understand how to compute the dynamics (angle, angular velocity, etc) of a rigidly rotating system in an exactly analogous way as you did with rotational motion. You should be able to compute the kinetic energy of a rotating body as well.

• Moment of inertia. You should know how to compute moment of inertia for individual point particles, as well as knowing how to apply the relations for spheres, rings, rods, etc. You should also be able to use the parallel axis theorem to compute the moment of inertia of bodies around points other than their centers of mass.

• Torque. You should be able to compute the torque on a system from the forces. In addition, you should be able to use arguments about rotational equilibrium to solve for the forces on extended bodies.

• Angular momentum. You should understand the relationship between the velocity and position of a particular, and how it's used to calculate angular momentum. In addition, you should be able to relate angular momentum and torque, and since an isolated body conserves angular momentum, you should be able to use angular momentum arguments to show how the rotation of a system will change if (say) it contracts or expands. Think of the merry-go-round problem.

Formula Sheet

Physical Constants

$$
\begin{aligned}
G &= 6.67 \times 10^{-11} Nm^2/kg^2 \\
g &= 9.8 m/s^2 \simeq 10 m/s^2 \\
c &= 3 \times 10^8 m/s
\end{aligned}
$$

Some useful math relations

$$
\begin{aligned}
\frac{dC}{dt} &= 0 \\
\frac{d(t^n)}{dt} &= nt^{n-1} \\
\frac{d(\cos(at))}{dt} &= -a\sin(at) \\
\frac{d(\sin(at))}{dt} &= a\cos(at) \\
x &= \frac{-b \pm \sqrt{b^2 - 4ac}}{2a} \quad \textit{Quadratic Formula}
\end{aligned}
$$

Projectile Relations

$$
\begin{aligned}
\Delta\vec{r} &= \vec{r}_f - \vec{r}_i \\
\vec{r} &= x\hat{i} + y\hat{j} \\
\vec{v} &= \frac{d\vec{r}}{dt} \\
\vec{a} &= \frac{d\vec{v}}{dt} \\
\vec{r}(t) &= \vec{r}_i + \vec{v}_i t + \frac{1}{2}\vec{a}t^2 \\
\vec{v}(t) &= \vec{v}_i + \vec{a}t \\
v_f^2 - v_i^2 &= 2\vec{a} \cdot \Delta\vec{r}
\end{aligned}
$$

Circular Motion

$$
\begin{aligned}
a_c &= \frac{v_t^2}{r} \\
a_t &= \frac{dv_t}{dt} \quad \textit{tangential acceleration}
\end{aligned}
$$

Newton's Laws

$$
\begin{aligned}
\vec{F} &= m\vec{a} \\
\sum \vec{F} &= 0 \quad \textit{equilibrium}
\end{aligned}
$$

Some specific forces

$$\begin{aligned} F_{g,y} &= -mg \\ F_s &= -kx \\ F_{G,r} &= -\frac{GMm}{r^2} \\ F_f &= \mu F_N \\ f &= -Cv^2 \ (air\ resistance) \\ f &= -kv \ (viscosity) \\ v_{esc} &= \sqrt{\frac{2GM}{r}} \\ v_c &= \sqrt{\frac{GM}{r}} \end{aligned}$$

Energy

$$\begin{aligned} K &= \frac{1}{2}mv^2 \\ W &= \vec{F} \cdot \Delta\vec{r} = F\Delta r \cos\theta \\ E_{mech} &= K + U \\ W &= \Delta E_{mech} \\ P &= \frac{dW}{dt} \\ &= \vec{F} \cdot \vec{v} \end{aligned}$$

Potential Energies

$$\begin{aligned} U_g &= mgy \\ U_s &= \frac{1}{2}kx^2 \\ U_G &= -\frac{GMm}{r} \\ F_x &= -\frac{dU}{dx} \end{aligned}$$

Momentum, Center of Mass, and collisions

$$\begin{aligned} M &= \sum_i m_i \\ \vec{r}_{com} &= \frac{\sum_i m_i \vec{r}_i}{M} \\ \vec{v}_{com} &= \frac{\sum_i m_i \vec{v}_i}{M} \\ \vec{p} &= m\vec{v} \\ \vec{J} &= \vec{F}\Delta t = \Delta\vec{p} \\ \vec{F} &= \frac{d\vec{p}}{dt} \end{aligned}$$

$$
\begin{aligned}
p_{1f} &= p_{1i}\left(\frac{m_1 - m_2}{m_1 + m_2}\right) \; 1-d\ elastic \\
p_{2f} &= p_{1i}\left(\frac{2m_2}{m_1 + m_2}\right) \; 1-d\ elastic
\end{aligned}
$$

Rotational Coordinates

$$
\begin{aligned}
s &= r\theta \\
\omega &= \frac{d\theta}{dt} \\
&= rv_t \\
\alpha &= \frac{d\alpha}{dt} \\
&= ra_t \\
\theta(t) &= \theta_0 + \omega_0 t + \frac{1}{2}\alpha t^2 \\
\omega(t) &= \omega_0 + \alpha t \\
K_{rot} &= \frac{1}{2} I \omega^2 \\
\tau &= I\alpha \\
&= F_\perp r \\
&= Fr\sin\phi \\
\sum \tau &= 0 \;\; (rot.\ equilibrium) \\
L &= I\omega \\
&= mv_\perp r \; (point\ particle) \\
\tau &= \frac{dL}{dt} \\
W &= \tau \Delta\theta
\end{aligned}
$$

Moment of Inertia

$$
\begin{aligned}
I &= \sum_i m_i r_i^2 \\
I_{ring} &= MR^2 \\
I_{disk} &= \frac{1}{2}MR^2 \\
I_{spherical\ shell} &= \frac{2}{3}MR^2 \\
I_{solid\ sphere} &= \frac{2}{5}MR^2 \\
I_{rod} &= \frac{1}{2}ML^2 \\
I &= I_{com} + Mh^2
\end{aligned}
$$

Rocket Science

$$
v = v_e \ln(M_i/M_f)
$$