MASSACHUSETTS INSTITUTE OF TECHNOLOGY
Department of Physics

Physics 8.01 Fall 2000

REVIEW QUIZ 2
FORMULA SHEET
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Equations introduced in Chapter 1:

$$\vec{\mathbf{v}} = \frac{\mathrm{d}\vec{\mathbf{r}}}{\mathrm{d}t}\,; \qquad \vec{\mathbf{a}} = \frac{\mathrm{d}\vec{\mathbf{v}}}{\mathrm{d}t} = \frac{\mathrm{d}^2\vec{\mathbf{r}}}{\mathrm{d}t^2}\,; \qquad \vec{\mathbf{r}}(t_1) = \vec{\mathbf{r}}_0 + \int_0^{t_1} \vec{\mathbf{v}}\,\mathrm{d}t\,; \qquad \vec{\mathbf{v}}(t_1) = \vec{\mathbf{v}}_0 + \int_0^{t_1} \vec{\mathbf{a}}\,\mathrm{d}t\ .$$

For *constant* acceleration $\vec{\mathbf{a}}$, if $\vec{\mathbf{r}} = \vec{\mathbf{r}}_0$ and $\vec{\mathbf{v}} = \vec{\mathbf{v}}_0$ at time $t = 0$, then

$$\vec{\mathbf{v}}(t) = \vec{\mathbf{v}}_0 + \vec{\mathbf{a}}t$$

$$\vec{\mathbf{r}}(t) = \vec{\mathbf{r}}_0 + \vec{\mathbf{v}}_0 t + \frac{1}{2}\vec{\mathbf{a}}t^2\ .$$

For one-dimensional motion with constant acceleration a:

$$v^2 = v_0^2 + 2a(x - x_0)\ .$$

For circular motion at constant speed v:

$$a = \frac{v^2}{r}\ ,$$

where r is the radius of the circle, and the acceleration is directed towards the center of the circle.

If an object has position $\vec{\mathbf{r}}$ and velocity $\vec{\mathbf{v}}$, its position and velocity relative to an observer with position $\vec{\mathbf{r}}_0$ and velocity $\vec{\mathbf{v}}_0$ are given respectively by

$$\vec{\mathbf{r}}' = \vec{\mathbf{r}} - \vec{\mathbf{r}}_0\ , \qquad \vec{\mathbf{v}}' = \vec{\mathbf{v}} - \vec{\mathbf{v}}_0\ .$$

Average velocity and acceleration are given by

$$\vec{\mathbf{v}}_{\text{average}} = \frac{\Delta\vec{\mathbf{r}}}{\Delta t}\ , \qquad \vec{\mathbf{a}}_{\text{average}} = \frac{\Delta\vec{\mathbf{v}}}{\Delta t}\ .$$

Equations introduced in Chapter 2:

$\vec{\mathbf{F}} = m\vec{\mathbf{a}}$	(Newton's second law);
$\vec{\mathbf{F}} = -\frac{GMm}{r^2}\hat{\boldsymbol{r}}$	(the gravitational force between two particles);
$\vec{\mathbf{F}} = \frac{1}{4\pi\epsilon_0}\frac{Qq}{r^2}\hat{\boldsymbol{r}}$	(the electrostatic force between two particles);
$F_x = -kx$	(Hooke's law);
$\frac{\mathrm{d}^2x}{\mathrm{d}t^2} = -\omega^2 x$	(for a particle near a point of stable equilibrium; equation leads to simple harmonic motion);
$x = A\sin\omega t$	(a solution to the above equation; any solution can be written this way if we choose $t = 0$ when $x = 0$);
$\omega = 2\pi f$	(relation between angular frequency and frequency);
$T = \frac{1}{f} = \frac{2\pi}{\omega}$	(period of an oscillator).

Equations introduced in Chapter 4:

1 Dimension	**3 Dimensions**	**Description**
$W \equiv F\Delta x$	$W \equiv \vec{\mathbf{F}} \cdot \overrightarrow{\mathbf{\Delta r}}$	Work done by a constant force $\vec{\mathbf{F}}$
$W \equiv \int F(x)\,\mathrm{d}x$	$W \equiv \int_{\vec{\mathbf{r}}_1}^{\vec{\mathbf{r}}_2} \vec{\mathbf{F}} \cdot \overrightarrow{\mathbf{dr}}$	Work done by a varying force $\vec{\mathbf{F}}$
$U(x_p) \equiv U_0 - \int_{x_0}^{x_p} F\,\mathrm{d}x$	$U(\vec{\mathbf{r}}_p) \equiv U_0 - \int_{\vec{\mathbf{r}}_0}^{\vec{\mathbf{r}}_p} \vec{\mathbf{F}} \cdot \overrightarrow{\mathbf{dr}}$	Potential energy derived from force $\vec{\mathbf{F}}$
$F = -\frac{\mathrm{d}U}{\mathrm{d}x}$	$\vec{\mathbf{F}} = \left[-\frac{\partial U}{\partial x}, -\frac{\partial U}{\partial y}, -\frac{\partial U}{\partial z}\right]$	Force derived from potential energy

$\vec{\mathbf{a}} \cdot \vec{\mathbf{b}} = \lvert\vec{\mathbf{a}}\rvert\lvert\vec{\mathbf{b}}\rvert \cos\theta$	(scalar (or dot) product of two vectors)
$= a_x b_x + a_y b_y + a_z b_z$	
$\frac{1}{2}mv^2 + mgh = \frac{1}{2}mv_0^2$	(kinetic & potential energy for projectile)
$\frac{1}{2}mv^2 + U(x) = \text{constant}$	(energy conservation)
$W = K_f - K_i$	(work-energy theorem)
$U = \frac{1}{2}kx^2$	(potential energy for spring force)
$U = mgh$	(gravitational potential energy, near Earth)
$U = -\frac{GMm}{r}$	(gravitational potential energy, spherical bodies)

Equations introduced in Chapter 5:

$\vec{\mathbf{F}}_{\mathrm{AB}} = -\vec{\mathbf{F}}_{\mathrm{BA}}$	(Newton's third law);
$\vec{\mathbf{p}} = m\vec{\mathbf{v}}$	(momentum);
$\frac{\mathrm{d}\vec{\mathbf{P}}_{\mathrm{tot}}}{\mathrm{d}t} = 0$	(conservation of momentum in absence of external force)
$\vec{\mathbf{F}} = \frac{\mathrm{d}\vec{\mathbf{p}}}{\mathrm{d}t}$	(Newton's second law in terms of momentum);
$\vec{\mathbf{r}}_{\mathrm{cm}} \equiv \frac{1}{M_{\mathrm{tot}}} \sum_i m_i \vec{\mathbf{r}}_i$	(position of center of mass);
$\vec{\mathbf{v}}_{\mathrm{cm}} \equiv \frac{\mathrm{d}\vec{\mathbf{r}}_{\mathrm{cm}}}{\mathrm{d}t} = \frac{1}{M_{\mathrm{tot}}} \sum_i m_i \vec{\mathbf{v}}_i$	(velocity of center of mass);
$\vec{\mathbf{F}}^{\mathrm{ext}}_{\mathrm{tot}} = M_{\mathrm{tot}} \vec{\mathbf{a}}_{\mathrm{cm}} = \frac{\mathrm{d}\vec{\mathbf{P}}_{\mathrm{tot}}}{\mathrm{d}t}$	(acceleration of a system of particles);
$\vec{\mathbf{P}}_{\mathrm{tot}} = \sum_i m_i \vec{\mathbf{v}}_i = M_{\mathrm{tot}} \vec{\mathbf{v}}_{\mathrm{cm}}$	(momentum of a system of particles);
$K_{\mathrm{tot}} = \frac{1}{2} M_{\mathrm{tot}} v_{\mathrm{cm}}^2 + \sum_i \frac{1}{2} m_i \left(\vec{\mathbf{v}}_i - \vec{\mathbf{v}}_{\mathrm{cm}}\right)^2$	(K.E. of a system of particles);
$\vec{\mathbf{J}} = \int_{t_1}^{t_2} \vec{\mathbf{F}}\, \mathrm{d}t = \int_{t_1}^{t_2} \frac{\mathrm{d}\vec{\mathbf{p}}}{\mathrm{d}t}\, \mathrm{d}t = \vec{\mathbf{p}}_2 - \vec{\mathbf{p}}_1$	(impulse-momentum theorem).