

Engineering Physics I – Fall 2015

Midterm 3 information

Midterm 3 will cover the material presented in lectures 15 through 21, the Monday lab sessions after midterm 2, and problem sets 8-10. This corresponds to Chapters 8-10 in your textbook, plus parts of chapter 13. Midterm 3 will not focus on the material covered in earlier lectures, though some of the equations we have used previously may be applicable to the problems in midterm 3.

You will need to memorize the following equations. They will not be provided for you on the midterm. You should also know how to apply these equations and under what circumstances they are applicable (for example, Newton's laws are only applicable in an inertial reference frame, and the kinematic equations only apply under constant acceleration).

$$\mathbf{p} = m\mathbf{v} \quad (\text{linear}) \text{ momentum}$$

$$\mathbf{J} = \mathbf{F}\Delta t = \Delta\mathbf{p} \quad \text{Impulse } \mathbf{J}$$

$$\mathbf{F} = d\mathbf{p}/dt = m\mathbf{a} \quad \text{alternate expressions of Newton's 2}^{\text{nd}} \text{ law}$$

$$\mathbf{r}_{\text{cm}} = (\sum m_i \mathbf{r}_i) / M_{\text{total}} \quad \text{position of the center of mass of a system of particles}$$

$$\mathbf{P}_{\text{total}} = M_{\text{total}} \mathbf{V}_{\text{CM}} \quad \text{total momentum of a system of particles can be described in terms of the total mass and the motion of the center of mass}$$

$$I = \sum m_i r_i^2 \quad (\text{how to calculate the moment of inertia } I \text{ given a number of discrete masses } m_i)$$

You will not be required to memorize moments of inertia for specific objects, e.g. that $I = \frac{2}{5} M R^2$ for a sphere rotating around an axis at its center. These will be given to you if needed.

$$I_p = I_o + Md^2 \quad \text{parallel axis theorem, given } I \text{ for an axis at point } O, \text{ the moment of inertia for an axis at point } P \text{ } I_p \text{ can be found from the } d, \text{ distance from } O \text{ to } P$$

$$\theta(t) = \theta_0 + \omega_0 t + \frac{1}{2}\alpha t^2 \quad \text{and} \quad \omega(t) = \omega_0 + \alpha t \quad (\text{if } \alpha \text{ is constant})$$

$$v_{\text{tangential}} = r\omega \quad \text{always holds for a rotating object – how to relate rotational velocity to linear tangential velocity}$$

$$v_{\text{cm}} = r\omega \quad \text{requirement for pure roll or motion without slipping}$$

$$a_{\text{tangential}} = r\alpha \quad \text{always holds for a rotating object – how to relate rotational acceleration to linear tangential acceleration (but remember there is also a centripetal acceleration that is radial!)}$$

$$\boldsymbol{\tau} = I\boldsymbol{\alpha} = \mathbf{r} \times \mathbf{F} = d\mathbf{L}/dt$$

$$\mathbf{L} = I\boldsymbol{\omega} = \mathbf{r} \times \mathbf{p}$$

$$KE_{\text{rotation}} = \frac{1}{2} I\omega^2 \text{ (kinetic energy of rotation)}$$

$$KE_{\text{total}} = KE_{\text{translation}} + KE_{\text{rotation}} \quad \text{(total kinetic energy of an object undergoing both translation, or linear motion, and rotation)}$$

$$T = a^{3/2} \quad \text{Kepler's 2nd law, orbital period of a planet T in years, a is semi-major axis in AU}$$

You are also expected to know the following equations (from midterms 1 & 2):

$$x(t) = x_0 + v_{0,x}t + \frac{1}{2}a_x t^2 \quad y(t) = y_0 + v_{0,y}t + \frac{1}{2}a_y t^2$$

$$v_x(t) = v_{0,x} + a_x t \quad v_y(t) = v_{0,y} + a_y t$$

$$\text{Force due to kinetic friction} \quad \mathbf{F} = \mu_k \mathbf{N}$$

$$\text{Force due to static friction} \quad \mathbf{F} \leq \mu_s \mathbf{N}$$

$$a_c = \frac{v^2}{R} \quad \text{centripetal acceleration (radial)}$$

$$W = \int \mathbf{F} \cdot d\mathbf{s}$$

$$W = \mathbf{F} \cdot \mathbf{s} \text{ (if force is constant)}$$

$$W = \Delta KE \text{ (work-energy theorem)}$$

$$\mathbf{F} = k\mathbf{x} \text{ (force required to stretch a spring a distance x)}$$

$$KE = \frac{1}{2} mv^2 \text{ (kinetic energy of translational motion)}$$

$$\frac{1}{2} mv_1^2 + mgy_1 = \frac{1}{2} mv_2^2 + mgy_2 \quad \text{(conservation of mechanical energy if there are no other forces than gravity, no rotation)}$$

$$KE_1 + U_1 + W_{\text{other}} = KE_2 + U_2 \quad \text{(if other forces act on an object)}$$

Finally, the following equations are all included elsewhere in this document but it may help you to study them in the following way, relating linear motion to rotational motion:

Linear/translational motion	Rotational motion analogue
x	θ
v	ω
a	α
m	I
$F = ma$	$\tau = I\alpha$
$F = dp/dt$	$\tau = dL/dt$
$p = mv$	$L = I\omega$
$KE = \frac{1}{2}mv^2$	$KE_{\text{rot}} = \frac{1}{2} I\omega^2$