

PHY111 HS2020
Prof. Ben Kilminster

Midterm will be 25% of your total grade

Midterm date/time/place :

Thurs., 29. Oct. 2020 / 13:00-14:45 in your assigned exercise session

The mid-term will be based on the lecture material up to and including week 5 (including October 16), and HW05.

Here is a guide for things you should know, and things you should know how to do if you want to do well on the mid-term. You can learn these items best by using them to do your homework exercises, and the lecture exercises multiple times. Every physics textbook has additional exercises you can use to test your knowledge. **In physics, you have to practice exercises to learn !**

"What you should know for the mid-term"

- 1) Know how to add vectors, and how to calculate dot products and cross-products.
- 2) Know how to identify the forces we have studied: gravitational force, spring force, centripetal force, frictional force, normal force, pulling, pushing, tension. Learn the formulas for these.
- 3) Know Newton's three laws, and how to use them to determine the forces and movement of objects, both in the case of equilibrium and in the case of a net force.
- 4) Know how to figure out the work done by a force.
- 5) Know how to figure out the potential energy stored by an object, and how it relates to the work done by a force.
- 6) Know how to calculate the stored potential energy starting with the forces, using the formula for work, $W = -\Delta U = \int \mathbf{F} \cdot d\mathbf{x}$. You should be able to do this for the forces in (2).
- 7) Know the formula for kinetic energy, and when kinetic energy plus potential energy conservation is appropriate to use.
- 8) Know the formula for momentum, how to use momentum conservation, and when it is appropriate to use.
- 9) Know how to apply energy conservation to solve problems with the different types of energy we have studied.

- 10) Know how to determine whether a force is conservative or not.
- 11) Be familiar with the formulas for constant acceleration. For instance, if we give you the formula, $v = v_0 + at$, you should be able to integrate this to get $x = x_0 + v_0 t + \frac{1}{2}at^2$. (If needed, we will provide other formulas like $v^2 = v_0^2 + 2a\Delta x$ since they take a few minutes to derive.)
- 12) Know the formulas for angular velocity, angular acceleration, and angle: $\omega = v/r$, $\alpha = a/r$, $\theta = s/r$.
- 13) Be familiar with the formulas for constant angular acceleration. For instance, if we give you $\omega = \omega_0 + \alpha t$, you should be able to integrate to get $\theta = \theta_0 + \omega_0 t + \frac{1}{2}\alpha t^2$.
- 14) Know how to calculate position, velocity, and acceleration for 2-D motion with either gravitational acceleration or centripetal acceleration.
- 15) Know how to use X,Y,Z coordinates, as well as r, theta, phi coordinates.
- 16) Know the formulas for how force, momentum, and impulse relate.
- 17) Know how to calculate the center of mass of a system.
- 18) Know how to calculate the moment of inertia of a rotating object. You should be able to do this for simple objects like rods, disks, cylinders or spheres. You should also know how to apply the parallel axis theorem (Steiner's theorem) to calculate the moment of inertia through a different axis of rotation.
- 19) Know the formula for torque in terms of force and radius, as well as Newton's law for rotation, that relates the sum of torques to moment of inertia and angular acceleration.
- 20) Know how to calculate the angular momentum of a rotating object.
- 21) Know when and how to apply angular momentum conservation.
- 22) Know how torque and angular momentum are related.
- 23) Understand how to use the right-hand rule for torque, and angular momentum, as well as changes in angular momentum resulting from torque.
- 24) Be able to study a problem and determine which direction these vectors point : θ , ω , α , L , τ .
- 25) Know how to determine the kinetic energy of rotation, and the work and power done to rotate an object.
- 26) Know the rolling condition, and how an object can have both rotational kinetic

energy and linear kinetic energy. Know how the angular velocity and the linear velocity are related for a rolling object.

27) Know what precession is, and how to calculate it from a system with changing angular momentum due to a torque.

28) Know your units for all variable. Know how to convert units.

Formulas you should memorize and learn how to use. You may be asked to derive more specific formulas from these.

Linear motion :

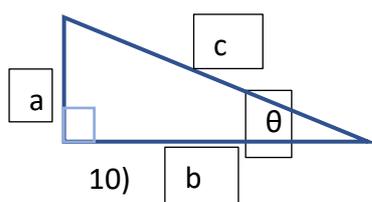
- 1) $v = v_0 + at$ (velocity in constant acceleration)
- 2) $F_g = mg$ (force of gravity)
- 3) $F = -kx$ (force for a spring)
- 4) $F_f = \mu F_N$ (force of friction)
- 5) $\mathbf{p} = m\mathbf{v}$ (linear momentum)
- 6) $\Sigma \mathbf{F} = m\mathbf{a} = d\mathbf{p}/dt$ (Newton's 2nd law)
- 7) $W = -\Delta U = \int (\mathbf{F} \cdot d\mathbf{x})$ (work and potential energy of a force)
- 8) $W_{\text{total}} = \Delta K$ (Work-energy theorem)
- 9) $K = \frac{1}{2}mv^2$ (Linear kinetic energy)
- 10) $P = \mathbf{F} \cdot \mathbf{v}$ (power from a force)

Rotational motion :

- 1) $\omega = \omega_0 + \alpha t$ (angular velocity in constant angular acceleration)
- 2) $I = \Sigma mr^2 = \int r^2 dm$ (rotational inertia)
- 3) $F = mv^2/r$ (centripetal force)
- 4) $\boldsymbol{\tau} = \mathbf{r} \times \mathbf{F}$ (torque and force)
- 5) $\mathbf{L} = \mathbf{r} \times \mathbf{p}$ (angular momentum)
- 6) $\Sigma \boldsymbol{\tau} = I\boldsymbol{\alpha} = d\mathbf{L}/dt$ (torque and angular velocity)
- 7) $W = \int (\boldsymbol{\tau} \cdot d\boldsymbol{\theta})$ (work of a torque)
- 8) $K = \frac{1}{2}I\omega^2$ (rotational kinetic energy)
- 9) $P = \boldsymbol{\tau} \cdot \boldsymbol{\omega}$ (power from a torque)

General things to know :

- 1) $\alpha = a/r, \omega = v/r, \theta = s/r$ (Relation between rotational \leftrightarrow linear motion;
(also these are the rolling conditions)
(Notice : you can derive many of the rotational equations from the linear equations using these relationships)
- 2) $\mathbf{c} = \mathbf{a} \cdot \mathbf{b} = ab \cos\theta$ dot product of vectors
- 3) $\mathbf{c} = \mathbf{a} \times \mathbf{b} = ab \sin\theta$ cross product of vectors
- 4) Know basic derivatives and integrals of polynomials, $\sin \theta, \cos \theta$
- 5) Know relationship between ω and period, T
- 6) Know how to convert between degrees and radians
- 7) Know geometric rules for a triangle :



10)

$$\begin{aligned} \sin \theta &= a/c \\ \cos \theta &= b/c \\ \tan \theta &= a/b \\ a^2 + b^2 &= c^2 \end{aligned}$$