Physics 101H

General Physics 1 – Honors

Lecture 50 – 12/08/22

Review I

Final

Exam takes place in **Small 111** from **9 am to 12 noon** on **Tuesday December 13**

You will have 3 hours to complete the exam

- 5 multiple choice questions
- 5 handwritten solution problems

Arrive early, bring paper and something(s) to write with! (Spare paper will be available)

Topics cover Chapters 1 to 17

- Practice exam is available on Blackboard
- Solutions will be available after class tomorrow on Blackboard

You may prepare your own formula sheet – **two sides** of **letter paper**

You may bring a calculator, but phones, tablets and laptops are not allowed

Remember you are here to learn and understand the physics!

Topic overview: part I

Preliminaries:

- Dimensional analysis and units
- Vectors, including dot and cross products

1D kinematics:

- Distinguishing scalar and vector quantities
- Kinematic equations for constant acceleration

2D kinematics:

- Kinematic equations for constant acceleration
  - Projectile motion
- Uniform circular motion

Dynamics

- Newton’s laws of motion

Topic overview: part II

Work and energy conservation:

- Work and work-energy theorem
- Conservative forces
- Kinetic energy and potential energy
- Conservation of energy
- Power

Momentum and collisions:

- Conservation of momentum
- Elastic and inelastic collisions
- Collisions in 1D and 2D

Rotational motion:

- Rotational kinematics
- Relating angular and linear kinematics
- Moment of inertia
- Conservation of energy

Rotational dynamics:

- Torque
- Newton's second law for rotational motion
- Angular momentum
- Conservation of angular momentum
- Rolling motion

Topic overview: part III

Static equilibrium and elasticity:

- Definition of equilibrium
- Stress and strain
- Elastic modulus

Gravitation:

- Newton's law of gravitation
- Gravitational potential energy
- Kepler's laws
- Orbital energy
- Escape velocity

Fluid mechanics:

- Density and pressure
- Pascal's principle
- Archimedes' principle
- Continuity equation
- Bernoulli's principle

Topic overview: part III

Oscillatory motion:

- Simple harmonic motion
- Simple harmonic vs circular motion
- Pendulums
- Damped and forced oscillations

Waves:

- Wave equation and travelling waves
- Waves on a string
- Wave superposition and interference
- Reflection and transmission
- Standing waves

Sound:

- Sound waves
- Sound intensity and sound intensity level
- Beats
- Doppler effect

Mechanics survey

Instructions: Please complete the following multiple choice survey. The survey is **ungraded**, and is intended to help the department understand how to help you learn physics. You score **does not matter** and you will receive **participation credit**.

Please **write your name** on the cover sheet. You will receive **extra credit** for completing the survey. (I will include it as part of your grade for Problem Set 0.)

You have 30 minutes. Answer **as many questions as you can.**

You **may not use electronic devices: phones, tablets, laptops, etc.**

PHYSICS 101 - HONORS

Lecture 50 12/8/22

Key equations

Part 1

$$\bar{a}\cdot\bar{b} = ab\cos\theta$$

$$\bar{a}\times\bar{b} = \begin{vmatrix} \hat{i} & \hat{j} & \hat{k} \\ a_x & a_y & a_z \\ b_x & b_y & b_z \end{vmatrix} = \hat{i}(a_y b_z - b_y a_z) - \hat{j}(a_x b_z - a_z b_x) + \hat{k}(a_x b_y - a_y b_x)$$

$$\bar{x} = \frac{\bar{a}t^2}{2} + \bar{v}_0 t + \bar{x}_0$$

$$\bar{v} = \bar{v}_0 + \bar{a}t$$

$$\Delta\bar{x} = \left(\frac{\bar{v} + \bar{v}_0}{2}\right)t$$

$$v^2 = v_0^2 + 2a\Delta x$$

$$h = \frac{v_0^2}{2g}\sin^2\theta$$

$$R = \frac{2v_0^2}{g}\sin\theta\cos\theta$$

$$a_c = \frac{v^2}{r} = \omega^2 r$$

$$v = \omega r$$

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

$$\bar{F}_{net} = m\bar{a}$$

$$F_s \le \mu_s N$$

$$F_k = \mu_k N$$

$$g = 9.81\ m/s^2$$

Part II

$$W = \int \bar{F} \cdot d\bar{r}$$

$$W = \Delta E_K = \frac{1}{2} m v_2^2 - \frac{1}{2} m v_1^2$$

$$W = \Delta E_p = \frac{k}{2}\left(x_2^2 - x_1^2\right)$$ for a spring

$$W = \Delta E_g = -mg\,(y_2 - y_1)$$ close to Earth's surface

$$P = \frac{dW}{dt} = \bar{F} \cdot \bar{v}$$

conservation of energy: $E^i_{TOT} = E^f_{TOT}$

$$\bar{p} = m\bar{v}$$

$$\bar{I} = \int \bar{F}\, dt = \Delta \bar{p}$$

$$\bar{F} = \frac{d\bar{p}}{dt}$$ ← Newton's 2nd law (!)

Conservation of $\bar{p}_f = \bar{p}_i$

$$\bar{r}_{cm} = \frac{1}{M}\int \bar{r}\, dm \qquad \bar{v}_{cm} = \frac{d}{dt}\bar{r}_{cm} \qquad \bar{a}_{cm} = \frac{d\bar{v}_{cm}}{dt}$$

$$\Delta v = u \ln \frac{m_i}{m_f}$$ rocket equation

Rotational

$$\bar{\omega} = \frac{d\bar{\theta}}{dt}$$

$$\bar{\alpha} = \frac{d\bar{\omega}}{dt} = \frac{d^2\bar{\theta}}{dt^2}$$

$$\bar{\omega} = \bar{\alpha} t + \bar{\omega}_0$$

$$\bar{\theta} = \frac{\bar{\alpha}}{2} t^2 + \bar{\omega}_0 t + \bar{\theta}_0$$

$$I = \int r^2 \, dm \quad \text{or} \quad I = \sum_i r_i^2 m_i$$

$$E_K^{rot} = \frac{1}{2} I \omega^2$$

$$\bar{L} = \bar{r} \times \bar{p} = I \bar{\omega}$$

$$\bar{\tau} = \frac{d\bar{L}}{dt} = \bar{r} \times \bar{F}$$

$$\bar{\tau}_{net} = I \bar{\alpha}$$

Translational

$$\bar{v} = \frac{d\bar{x}}{dt}$$

$$\bar{a} = \frac{d\bar{v}}{dt} = \frac{d^2\bar{x}}{dt^2}$$

$$\bar{v} = \bar{a} t + \bar{v}_0$$

$$\bar{x} = \frac{\bar{a} t^2}{2} + \bar{v}_0 t + \bar{x}_0$$

$$E_K^{lin} = \frac{1}{2} m v^2$$

$$\bar{p} = m\bar{v}$$

$$\bar{F} = \frac{d\bar{p}}{dt}$$

$$\bar{F}_{net} = m\bar{a}$$

↖ ↗

$$s = r\theta$$

$$v_t = \omega r$$

$$\alpha = a_t / r$$

$$a_c = v_t^2 / r$$

connect rotational and translational motion

Part III

Static equilibrium:

$$\sum_k \bar{F}_k = 0 \qquad \sum_k \bar{\tau}_k = 0 \qquad \text{equilibrium}$$

$$e = \frac{\text{stress}}{\text{strain}} \qquad e = \frac{F_\perp / A}{\Delta L / L_0} \qquad \text{tensile stress / strain}$$

$$B = -\Delta p \frac{V_0}{\Delta V}$$

$$S = \frac{F_\parallel / A}{\Delta x / L_0}$$

Gravitation:

$$\bar{F}_{12} = \frac{G m_1 m_2}{r^2} \hat{r}_{12}$$

$$\bar{g} = \frac{GM}{r^2} \hat{r}$$

$$E_p = -\frac{G m_1 m_2}{r}$$

$$v_{esc} = \sqrt{\frac{2GM}{R}}$$

$$v_{orbit} = \sqrt{\frac{GM}{r}} \qquad T_{orbit} = 2\pi \sqrt{\frac{r^3}{GM}} \quad \text{or} \quad T^2 = \frac{4\pi^2}{GM} a^3$$

Kepler's 3rd law for an ellipse

Fluid mechanics:

$$\rho = \frac{m}{V}$$

$$p = \frac{F}{A} \qquad p = p_0 + \rho g h \qquad P_1 = P_2$$

↑ Pascal's principle

$$Q = \frac{dV}{dt}$$ flow rate

$$A_1 v_1 = A_2 v_2$$ continuity equation

$$p_1 + \frac{1}{2}\rho v_1^2 + \rho g h_1 = p_2 + \frac{1}{2}\rho v_2^2 + \rho g h_2$$ Bernoulli equation

Oscillations and waves:

$$f = \frac{1}{T} \qquad T = \frac{2\pi}{\omega}$$

$$x(t) = A\cos(\omega t + \phi) \qquad v(t) = -A\omega \sin(\omega t + \phi)$$

$$a(t) = -A\omega^2 \cos(\omega t + \phi)$$

$$\ddot{x} = -\omega^2 x$$ simple harmonic motion

$$\omega = \sqrt{\frac{k}{m}}$$ mass-spring system

$$\omega = \sqrt{\frac{g}{l}}$$ simple pendulum

$$x(t) = A e^{-\frac{b}{2m}t}\cos(\omega t + \phi)$$ underdamped pendulum

$$\omega = \sqrt{\omega_0^2 - \left(\frac{b}{2m}\right)^2}$$ underdamped frequency

$$x(t) = A\cos(\omega t + \phi)$$ forced oscillations

$$A = \frac{F_0}{\sqrt{m^2(\omega^2 - \omega_0^2)^2 + b^2\omega^2}}$$ forced oscillation amplitude

$v = f\lambda$ $\quad v = \dfrac{\lambda}{T}$ $\quad v = \dfrac{\omega}{k}$ wave speed

$v = \sqrt{\dfrac{T}{\mu}}$ string wave speed

$v = \sqrt{\dfrac{\beta}{\rho}}$ compression wave speed in fluid

$v = \sqrt{\dfrac{\gamma R T}{M}}$ sound wave in a gas

$y(x,t) = A \sin(kx \mp \omega t + \phi)$ travelling wave

$I = \dfrac{P}{4\pi r^2}$ spherical wave intensity (sound intensity)

$x(x,t) = x_{max} \cos(kx \mp \omega t + \phi)$
$P(x,t) = P_{max} \sin(kx \mp \omega t + \phi)$ sound waves

$$\frac{I_2}{I_1} = \frac{r_1^2}{r_2^2}$$

$\beta = 10 \log_{10} \dfrac{I}{I_0}$ $\quad I_0 = 10^{-12}\ \mathrm{W/m^2}$

$f_0 = f_s \left(\dfrac{v \pm v_0}{v \mp v_s}\right)$ Doppler effect