PHY138Y – Review for Test 1

Our approach has many times spiraled through the material.

Today we will put many pieces together.

Therefore, this review will not always be in the order in which we did things in class.

Reminders:

- You must bring:
  - Your student card
  - A dark-black soft-lead pencil
- The test is closed book
- You may bring:
  - 8 ½ x 11 inch sheet of paper on which you have written anything that you wish
  - A non-programmable calculator without text storage or communication abilities
- By design the test is "hard"

Format

- 8 Multiple Choice Questions
  - Correct answers get 8 marks
  - Incorrect answers get 0 marks
  - Non-answered questions get 0 marks
  - Multiple answers get 0 marks
- 1 Long Answer Question with 6 Parts (36 marks total)
  - Some partial credit given
  - Be sure to show your work

"Examsmanship"

- Answer the question you are asked
  - Some students insist on answering questions that are not being asked
- Multiple-Choice
  - Are some answers obviously wrong?
- Being calm and confident will allow you to do your best
- The "last minute cram" makes it much harder to be calm and confident
  - The cram is *proven* not to work in physics

Assumptions of Classical Physics

- The world is mechanistic, a "clockwork"
- The world is continuous
- The world is describable by mathematical *Laws*
- The description includes:
  - Everyday words with precise defns
  - Operational Definitions

Problem Solving

- Model
- Visualise
  - Pictorial, physical & graphical
- Guess the answer
- Solve
  - If numeric, put in numbers last
- Assess

Visualisation

- Choose coordinate system
  - “Reference Frame”
  - In principle arbitrary
- Define the *system* and the *environment*
- Graphs
- Motion Diagrams
- Free Body Diagrams
- Momentum Bar Charts
- Energy Diagrams

Where is the object?

- Displacement (vector) vs. Distance (scalar)
- Position vector $\vec{r}$
- If the object moves:
  - Displacement vector $\Delta\vec{r}$

Kinematics

Slopes - Derivatives ↓

$$\vec{x} = \vec{f}\,(t)$$

$$\vec{v} = \frac{d\,\vec{x}}{dt} = \vec{g}\,(t)$$

$$\vec{a} = \frac{d\,\vec{v}}{dt} = \frac{d^2\,\vec{x}}{dt^2} = \vec{h}\,(t)$$

Areas - Integrals ↑

“Fundamental Theorem of Calculus” (MAT135: §5.3)

Accelerations

- Constant
  - Free fall
- Non-constant
  - Uniform Circular Motion
  - Non-uniform Circular Motion
  - Spring-mass

Newton’s Laws

- Linear Momentum: $\vec{p} = m\vec{v}$
- 1st and 2nd Law: $\vec{F} = \frac{d\vec{p}}{dt} \Leftrightarrow d\vec{p} = \vec{F}\,dt$
  - Constant mass: $\vec{F} = m\vec{a} \Leftrightarrow \vec{a} = \frac{\vec{F}}{m}$
- 3rd Law: $\vec{F}_{1\,on\,2} = -\vec{F}_{2\,on\,1}$
  - Internal forces always cancel
- Tensions in strings
- Ballistocardiogram

This is almost all the Physics of the 1st Quarter!

Free Fall

- Projectile
- Weight **w** = m **g**
- Accelerating Reference Frames
  - “Non-inertial” – Newton’s Laws not true
  - Apparent weight $w_{app} = w(1 + a_y/g)$
- Gravitational Field
  1. M causes a field $\mathbf{E}_g$
  2. $\mathbf{E}_g$ causes a force on m placed in it

Circular Motion

- Centripetal Acceleration: $\frac{v^2}{r}\hat{r}$
- Uniform:
  - $a_{tangential} = 0$
- Non-uniform:
  - $a_{tangential} \neq 0$

Impulse & Momentum

- Impulse: $\vec{J} = \int_{t_1}^{t_2} \vec{F}\, dt = \Delta\vec{p}$
- Isolated system: momentum conserved
- All collisions: momentum conserved
- Damage to people in collisions:
  - $\Delta t < 100$ ms: Impulse
  - $\Delta t > 100$ ms: $a = F_{net}/m$

Work & Energy

- Isolated System: Total Energy Conserved
- Non-isolated System:
  - Work: $W = \int_{s_1}^{s_2} \vec{F} \cdot d\vec{s}$
  - Kinetic Energy: $K = \frac{1}{2} m v^2$
  - $W_{net} = \Delta K$ always
- $F_x = dW/dx$
- Elastic Collisions: K Conserved

Potential Energy

- Conservative Forces
  - W independent of path
  - The potential for work to be done: U
    - Arbitrary posn. where U = 0
  - $W = -\Delta U$
  - $E_{mech} = K + U$ conserved
  - $F_x = -dU/dx$ (From $F_x = +dW/dx$)
- Non-conservative Forces
  - U can not be defined

Power

- $P = dE_{sys}/dt$
- Basal (“Resting”) Metabolic Rate
  - Resting person: 60 – 90 Watts
  - Different organisms, mass m:
    - Dimensional analysis: bmr ~ $m^{2/3}$
    - Data: bmr ~ $m^{3/4}$
    - Fractal?

Centre of Mass (cm)

- Isolated Rigid Body: rotates about its centre of mass

$$\vec{r}_{cm} = \frac{1}{M}\int \vec{r}\, dm$$

Rotational Kinematics

- Particle: $\theta = \frac{s}{r}$ $\omega = \frac{v_t}{r}$ $\alpha = \frac{a_t}{r}$
- Rigid Body: θ ω α Same value for all points
- Both: $\omega = \frac{d\theta}{dt}$ $\alpha = \frac{d\omega}{dt}$

□ α = constant $\theta_f = \theta_i + \omega_i t + \frac{1}{2}\alpha t^2$

$s_f = s_i + v_i t + \frac{1}{2} a t^2$

Signs and Vectors for Rotational Quantities

- Counter-clockwise rotations: positive
- Clockwise rotations: negative
- Angular velocity **vector**:
  - Lies along axis of rotation
  - "Right hand screw" rule determines the direction.

Rotational Dynamics

- Particle: $L = m v r = m r^2 \omega$

  $I = m r^2$
- Rigid Body: $I = \int r^2 \, dm$
- Both: $\vec{L} = I \vec{\omega}$ $\vec{p} = m \vec{v}$

$\tau = F r \sin(\phi)$ $\vec{\tau} = \frac{d\vec{L}}{dt}$ $\vec{F} = \frac{d\vec{p}}{dt}$

Work – Energy Redux

- Work: $W = \int \tau \, d\theta$ $W = \int F \, ds$

  $W_{net} = \Delta K_{tot}$
- Kinetic Energy:

$K_{tot} = K_{trans} + K_{rot}$ $K_{rot} = \frac{1}{2} I \omega^2$ $K_{trans} = \frac{1}{2} m v_{cm}^2$

- Potential Energy: $U_g = mgy_{cm}$