PHYS 170 Study Notes

Mechanics

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Contents

1. General Principles

1.1. The Four Horseman of Mechanics

- Length
- Mass
- Time
- Force

So you basically take three of them and solve the 1 left.

1.2. US Customary Units

Length	Mass	Time	Force
meter m	kilogram kg	second s	force $\mathrm{kg\,m\,s^{-2}}$
foot ft	slug $\mathrm{lb\,s^2\,ft^{-1}}$	second s	pound lb

Table 1: SI and US Customary (FPS) Units for Mechanics

1.3. Gravity

$$F = G\frac{m_1 m_2}{r^2} \tag{1.1}$$

$$F = ma \tag{1.2}$$

In this course, we will use

$$g = 9.81\ \mathrm{m\,s^{-2}} \tag{2}$$

which happens to be true for Vancouver.

1.4. Vector Notation

In this course, vectors are upright bold, and vector magnitudes are italicized bold, while unit vectors are italics with an hat over.

$$\mathbf{A} \text{ has a magnitude of } \boldsymbol{A} \text{ in direction } \hat{\imath}. \tag{3}$$

1.5. Angle Unit

In this course, angles are in degrees.

2. Force Vectors

Force, having both magnitude and direction, is a vector. Intuitively, we can apply all kinds of vector operations to forces, as you would learn in MATH 152.

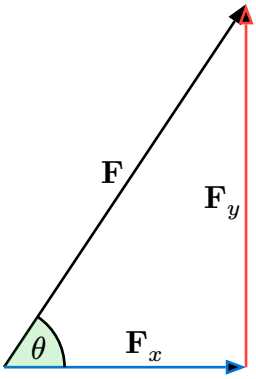
2.1. Addition

Use "tip to tail" for triangular method of addition: draw the vectors head to tail, and the resultant vector is the vector from the tail of the first vector to the head of the last vector.

2.2. Force Components

$$\mathbf{F} = x\hat{i} + y\hat{j} \tag{4}$$

where x, y are magnitudes of the force in the $\mathbf{i}, \mathbf{j}$ directions.



Force $\mathbf{F}$ can be represented as a combination of $\mathbf{F}_x$ and $\mathbf{F}_y$

$$\mathbf{F} = \mathbf{F}_x + \mathbf{F}_y \tag{5}$$

or as a polar coordinate of angle $\theta = \arctan\left(\frac{F_y}{F_x}\right)$ and magnitude F

$$\mathbf{F} = F(\cos(\theta) + \sin(\theta)). \tag{6}$$

To generalize it, we can write it as

$$\mathbf{F} = F_x\hat{i} + F_y\hat{j} \tag{7.1}$$

$$= F\left(\cos(\theta)\hat{i} + \sin(\theta)\hat{j}\right) \tag{7.2}$$

where $\hat{i}, \hat{j}$ are unit vectors in the x, y directions. This is the Cartesian form of a vector.

For a force with 2 dimensions, we call it a coplanar force.

Sometimes, non-linear equations arise from problems involving forces. Gladly use math solvers for those.

2.3. Unit Vector

To disregard magnitude and only focus on direction, we use unit vector, which we divide a vector by its magnitude, $\hat{u} = \frac{\mathbf{A}}{A}$.

2.4. 3D Forces

Forces in 3D are $\mathbf{F} = F_x\hat{i} + F_y\hat{j} + F_z\hat{k}$, with their magnitudes being $F = \sqrt{F_x^2 + F_y^2 + F_z^2}$.

To determine orientation of the axis, we use the right-hand rule: make a thumb up using your right hand, the side of the curling fingers is x, the arm is y, and the thumb is z.

3. Equilibrium of a Particle

4. Force System Resultants

5. Equilibrium of a Rigid Body

6. Friction

7. Kinematics of a Particle

8. Kinetics of a Particle: Force and Acceleration

9. Kinetics of a Particle: Work and Energy

10. Kinetics of a Particle: Impulse and Momentum