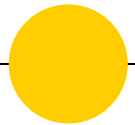
Physics 101H

General Physics 1 – Honors



Lecture 11 – 9/16/22

Newton's Laws and Forces

Quick quiz

*Quick quizzes incorporate *retrieval practice* and *interleaving*, in which we revisit older material to reinforce your understanding. By keeping track of answers that you can and can't write down without reference to your notes, these quizzes help you identify which topics and concepts you understand best and which you may need to keep reinforcing.

Instructions: This quiz is for your own learning. There are three questions and each question has two columns. Write your own solution, without reference to your notes, the textbook, or your neighbour, **in the first column**. Once you have tried to answer all the questions, discuss the questions with a neighbour and fill in any incomplete answers **in the second column**. Keep your sheet for future reference.

SCAN ME

Summary

Topics

Last week
- 2D motion
- Uniform circular motion
- Nonuniform motion
- Forces

This week
- Newton's laws
- Noninertial reference frames
- Work and energy

Friday: Forces
- Types of force
- Force examples

Today: Newton's laws [chapter 5]
- First law
- Second law
- Third law
- Forces in action

Announcements

This week: **No class on Thursday or Friday!**

What is your favourite force?

Newton's laws

Newton's laws relate the motion of an object to the forces acting on it

- First law
- Second law
- Third law

Example: A block slides down a frictionless plane that has an inclination of 20 degrees. The block starts from rest at the top of the plane and the length of the incline is 2 m. Find the: (a) acceleration of the block; (b) block's speed when it reaches the end of the incline.

Example: A 25 kg block is initially at rest on a horizontal surface. A horizontal force of 75 N is required to set the block in motion, after which a horizontal force of 60 N is required to keep the block moving at a constant speed. Find the coefficients of static and kinetic friction.

Two minute essay

Instructions: Write one paragraph on the following topic. You have two minutes. You may not use your notes and you should not consult with others around you. Your answer will not be graded; your answer is for your own learning and you don't need to share your answer.*

Question: Describe what happens if you hold a pendulum that is free to swing (such as a shoe on a shoestring) inside a plane accelerating down a runway during takeoff, and explain your reasoning.

Summary

Topics

This week

- Newton's laws
- Noninertial reference frames
- Work and energy

Today: Newton's laws [chapter 5]

- First law
- Second law
- Third law
- Forces in action

Wednesday: Noninertial frames

- Noninertial reference frames
- Fictitious/pseudo forces
  - Centrifugal "force"
  - Coriolis "force"
-

Announcements

This week: **No class on Thursday or Friday!**


THIS WEEK:
NO CLASS ON THURSDAY OR FRIDAY

PHYSICS 101 - HONORS

Lecture 11 9/16/22

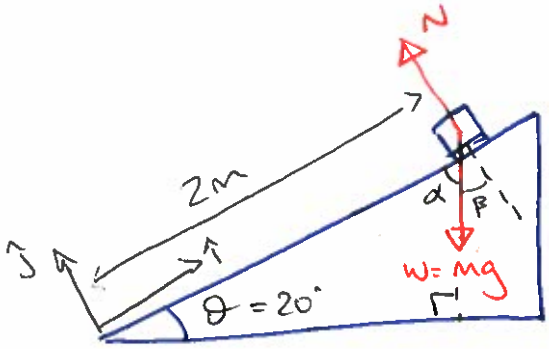
Newton's laws (slide 4)

1st: object in motion stays in motion, or, object at rest stays at rest, unless acted on by an external force

2nd: $F = ma$

3rd: for every action there is an equal and opposite reaction

Frictionless plane example



$\alpha = 90 - \theta$
$\beta = 90 - \alpha$
$= \theta$

- Pick a reference frame!
- Draw a diagram
- Identify forces
  - $\bar{N} = N\hat{j}$
  - $\bar{W} = -mg\sin\theta\,\hat{i} - mg\cos\theta\,\hat{j}$
- Identify acceleration direction
  - down the block $\bar{a} = -a\hat{i}$
- Equate forces and accelerations in each perpendicular direction

$\hat{j}$: $N - mg\cos\theta = 0 \Rightarrow N = mg\cos\theta$

$\hat{i}$: $-mg\sin\theta = -ma$

$a = g\sin\theta = \boxed{9.81\sin 20^\circ}$ down incline

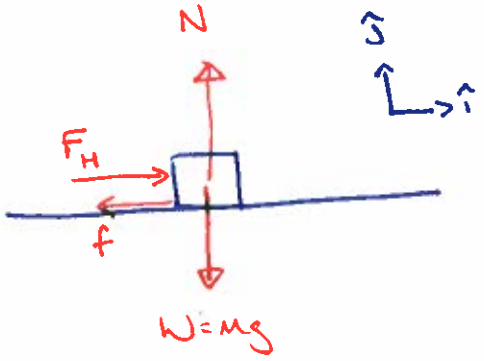
or $\boxed{\bar{a} = -3.36\ m/s^2\,\hat{i}}$

To find the speed, use $v_f^2 - v_i^2 = 2a\Delta x$

$\Rightarrow v_f^2 - 0 = 2 \cdot 9.81 \sin 20 \cdot 2 = 13.4209$

$\Rightarrow \boxed{v_f = 3.66 \text{ m/s}}$ N.B. no direction - asked for speed!

Friction example



- Pick a reference frame
- Draw a diagram
- Identify forces
  - $\bar{N} = N\hat{j}$
  - $\bar{W} = -mg\,\hat{j}$
  - $\bar{F}_H = F_H\,\hat{i}$ ← horizontal force
  - $\bar{f} = -f\,\hat{i}$ ← friction
- Identify acceleration
  - Before motion $\bar{a} = 0$ $\Rightarrow$
- Equate forces

$\hat{j}: N - mg = 0 \Rightarrow N = mg$

$\hat{i}: F_H - f = 0 \Rightarrow F_H = f$

Static friction is given by

$f_s \leq \mu_s N \Rightarrow f_s \leq \mu_s mg$

Slipping occurs at $f_H = 75$ N $\Rightarrow F_H = f_s = 75$ N

So $\mu_s = \frac{f_s}{mg} = \frac{F_H}{mg} = \frac{75}{25 \cdot 9.81} = \boxed{0.306}$ (dimensionless)

When moving $f_k = \mu_k N$

$\Rightarrow \mu_k = \frac{F_H}{mg} = \frac{F_H}{mg} = \frac{60}{25 \cdot 9.81} = \boxed{0.245}$