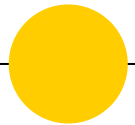
Physics 101H

General Physics 1 – Honors



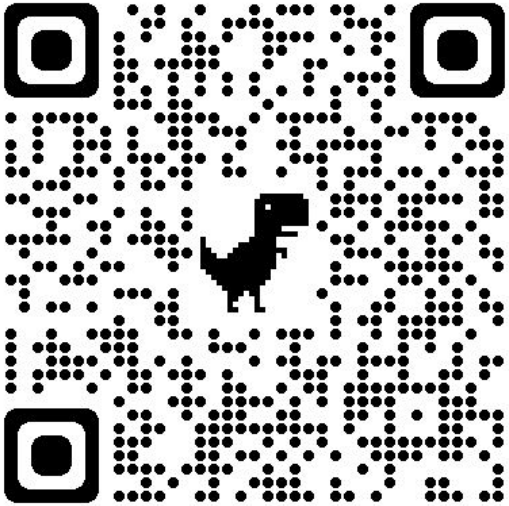
Lecture 12 – 9/20/23

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.



Summary

Topics

Monday: Forces [chapter 5]

- Types of forces
- Field forces and contact forces

Today: Newton's laws [chapter 5]

- First law
- Second law
- Third law

Announcements

Today: **Problem set 2 due**
Problem set 3 assigned

Tomorrow: **Quiz 3**

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 – an object remains at rest, or in a state of constant velocity, unless acted on by a net force

- Second law – acceleration of an object is equal to the net force on that object, divided by its mass

- Third law – "every action has an equal and opposite reaction"

Example 12.1: 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 12.2: 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

Today: Newton's laws [chapter 5]

- First law
- Second law
- Third law

Tomorrow:

- Noninertial reference frames
- "Fictitious" forces

Tomorrow is the **last** day to **opt out** (by emailing me) of having quizzes count as part of your final grade. Remember, everyone receives participation credit for taking the quizzes.

Announcements

Today: **Problem set 2 due**
Problem set 3 assigned

Tomorrow: **Quiz 3**

PHYSICS 101 - HONORS

Lecture 12 9/20/23

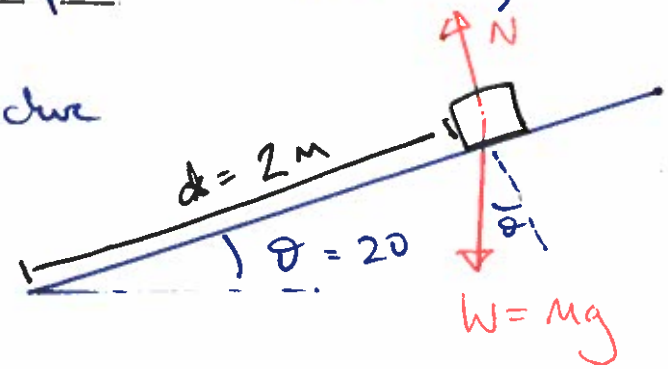
Newton's Laws (slide 5)

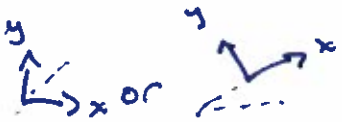
Newton II $\quad \bar{a} = \frac{\sum_i \bar{F}_i}{M}$

Newton III $\quad \bar{F}_{12} = -\bar{F}_{21}$

Block example (slide 6)

1. draw a picture



2. choose a reference frame – can choose  or

=> choose parallel and perpendicular to slope

3. Resolve components and apply $\sum_i \bar{F}_i = m\bar{a}$

parallel: $W \sin\theta = ma \quad \Rightarrow mg\sin\theta = ma$

$a = g\sin\theta$

perpendicular: $W\cos\theta \quad N = 0$

$\Rightarrow N = mg\cos\theta$ ← but for this example we don't need this

acceleration is $a = g\sin\theta$

$= 9.81 \cdot \sin 20^\circ \simeq \boxed{3.4\ m/s^2}$

For the second part, we start by writing down what we know

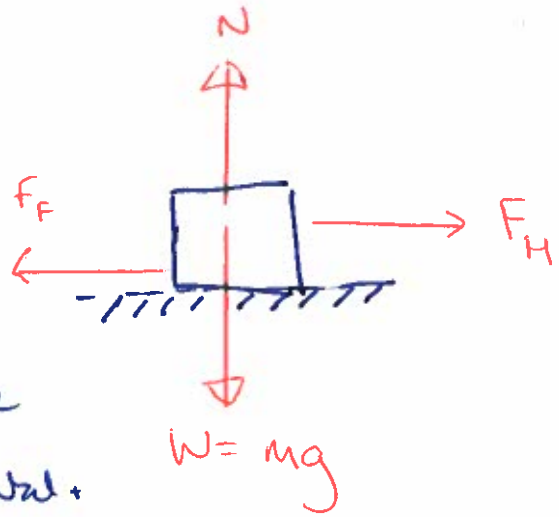
$x_0 = 0$ $\quad v_0 = 0$ $\quad a = -g\sin\vartheta$

$x = -2m$ $\quad v = ?$

$$v^2 = v_0^2 + 2a\Delta x$$
$$= 0^2 + 2(-g\sin\vartheta)(-2-0)$$
$$= 4g\sin\vartheta$$
$$\Rightarrow v = \sqrt{2g\sin\vartheta} \simeq \boxed{3.69\ m/s}$$

Friction example

1. draw a picture(s)



2. choose a reference frame

=> natural to pick horizontal + vertical

3. resolve components

$\updownarrow$: $N - mg = 0 \Rightarrow N = mg$

$\leftrightarrow$: $F_H^s - f_F^{static} = 0 \Rightarrow f_f^{static} = F_H^s$

or $F_H^k - f_F^{kinetic} = 0 \Rightarrow f_F^{kinetic} = F_H^k$

recall:

$f_F^{max} = \mu_s N$

$f_f^{kinetic} = \mu_K N$

$$\Rightarrow \quad \mu_s \cdot N = F_H^s$$

$$\mu_s = \frac{F_H^s}{N} = \frac{F_H^s}{mg} = \frac{75}{25 \cdot 981} = \boxed{0.31}$$

and $\quad \mu_k N = F_H^k$

$$\mu_k = \frac{F_H^k}{N} = \frac{P_H^k}{mg} = \frac{60}{25 \cdot 9.81} = \boxed{0.24}$$

Equation Summary

Newton II $\quad \sum_i \bar{F}_i = m\bar{a}$

Newton III $\quad \bar{F}_{12} = -\bar{F}_{21}$

Static friction $\quad F_s \leq \mu_s N$

Kinetic friction $\quad F_K = \mu_K N$