Name:______________________________ ID: ____________________

Physics 201

Midterm 2

11/12/2025

Collaboration is not allowed. Allowed on your desk are: ten 8.5 x 11 inch doubled-sided sheets of notes that are bound together, non-communicating graphing scientific calculator, a page of scratch paper, writing utensils, and the exam. You will have 80 minutes to complete this exam.

For questions 1 through 4 **fill in the square** next to all correct answers. A given problem may have more than one correct answer. Each correctly bubbled answer will receive two points. There are **7** correct answers in this section and only the first **7** filled in answers will be graded. There is no partial credit.

1. A ball is thrown, on earth, with an initial velocity approximately 40 degrees above the horizontal. Using a standard coordinate system, the initial velocity has both positive x- and y-components. We are interested in the time the ball is flying through the air.

(i) Which of the plots could represent the x-component of the ball's position as a function of time?

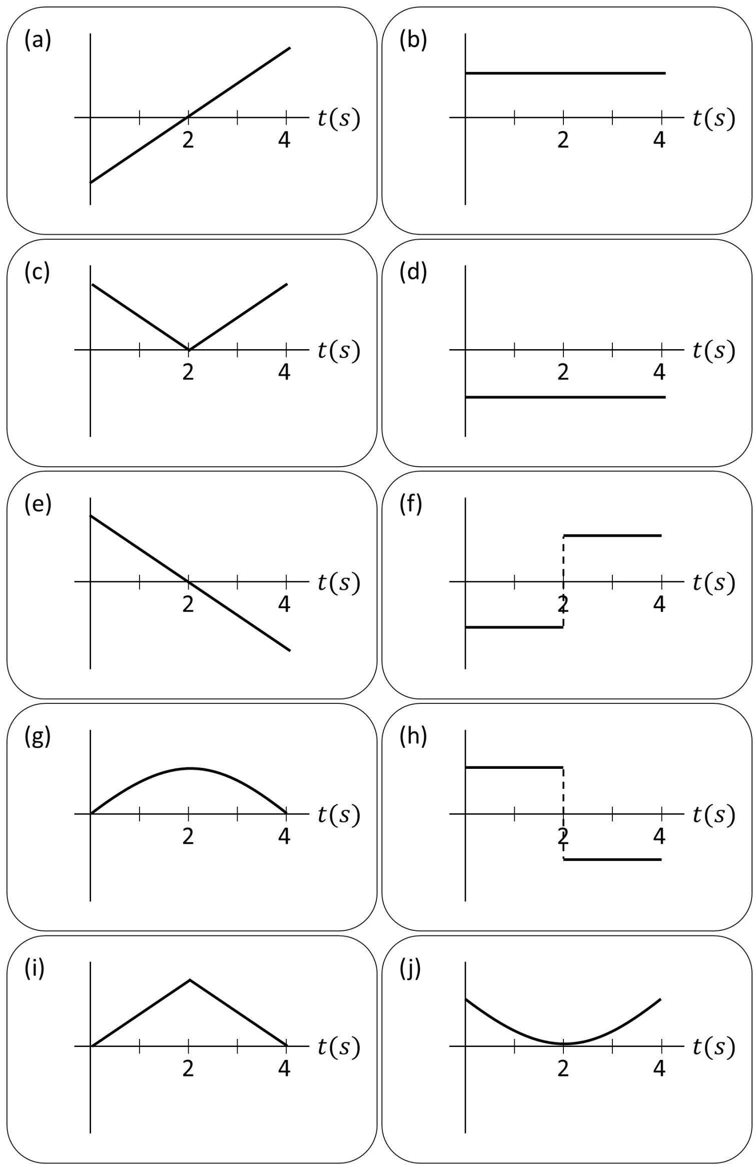
☑ (a) ☐ (b)
☐ (c) ☐ (d)
☐ (e) ☐ (f)
☐ (g) ☐ (h)
☐ (i) ☐ (j)

(ii) Which of the plots could represent the y-component of the ball's velocity.

☐ (a) ☐ (b)
☐ (c) ☐ (d)
☑ (e) ☐ (f)
☐ (g) ☐ (h)
☐ (i) ☐ (j)

(iii) Which of the plots could represent the y-component of the ball's acceleration?

☐ (a) ☐ (b)
☐ (c) ☑ (d)
☐ (e) ☐ (f)
☐ (g) ☐ (h)
☐ (i) ☐ (j)



Concepts assessed and Related Questions

Graphical Analysis
GA.L1.PRE/LEC/POST/CHW
K1.L1.2-08
K1.L2.1-05
Week 2 Challenge Homework

Two Dimensional Kinematics
K2.L2.2-02
K2.L2.2-08

2. Pictured here is an example of a "swing carousel". People sit in swing-like seats arranged in a circle around a center tower structure. The seats are attached using rope to the center tower. The tower, and thus the people, swing around in a horizontal, circular, path in uniform circular motion. Which of the following must be true while the people are swinging around the tower?

- ☐ (a) Each person will have an acceleration upwards to counteract gravity.
- ☐ (b) The net force on each person is zero.
- ☐ (c) The centripetal force pulls each person outwards as they travel in the circular path.
- ☑ (d) Each person has a net external force that is perpendicular to their velocity and points horizontally.
- ☐ (e) Each person's velocity is constant while in UCM.
- ☑ (f) Each person's speed is constant while in UCM.
- ☐ (g) Each person's acceleration is constant while in UCM.

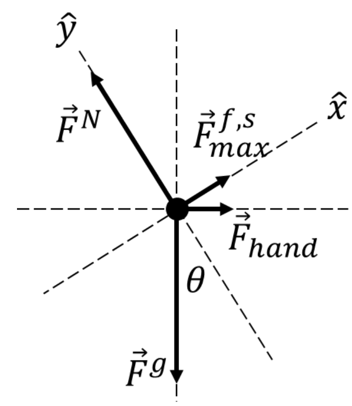
Concepts assessed and Related Questions

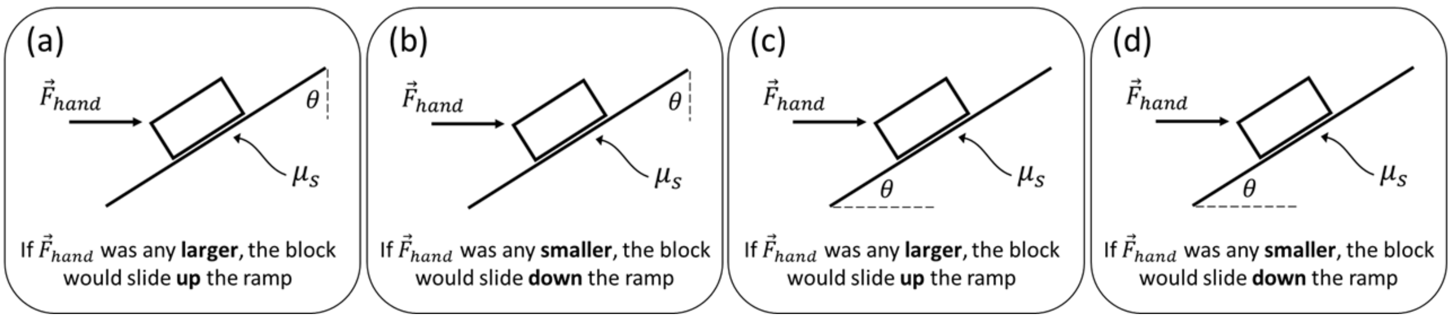
Uniform Circular Motion
N3.L2.PRE
N3.L2.LEC
N3.L2.POST
N3.L2.CHW
Week 6 Challenge Homework

3. The pictured free body diagram represents a stationary wooden block on a wooden ramp on which a hand is exerting a force.

   Which **one** of the following physical descriptions does this free body diagram best describe?

   ☐ (a) ☐ (b) ☐ (c) ☑ (d)





4. Refer to the previous question. Which set of the following Newton's 2nd Law equations would follow from the given free body diagram above?

☐ (a)

X: $-mg\cos\theta + \mu_s|\vec{F}^N| + |\vec{F}_{hand}|\sin\theta = ma_x$

Y: $-mg\sin\theta + |\vec{F}^N| - |\vec{F}_{hand}|\cos\theta = ma_y$

☐ (b)

X: $-mg\sin\theta - \mu_s|\vec{F}^N|\cos\theta + |\vec{F}_{hand}| = ma_x$

Y: $-mg\cos\theta + |\vec{F}^N| - |\vec{F}_{hand}|\sin\theta = ma_y$

☑ (c)

X: $-mg\sin\theta + \mu_s|\vec{F}^N| + |\vec{F}_{hand}|\cos\theta = ma_x$

Y: $-mg\cos\theta + |\vec{F}^N| - |\vec{F}_{hand}|\sin\theta = ma_y$

☐ (d)

X: $-mg\cos\theta + \mu_s|\vec{F}^N| + |\vec{F}_{hand}|\cos\theta = ma_x$

Y: $-mg\sin\theta + |\vec{F}^N| - |\vec{F}_{hand}|\sin\theta = ma_y$

Concepts assessed and Related Questions

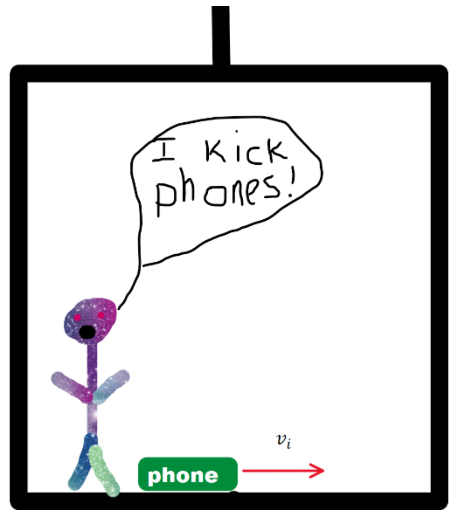
Force Analysis
N1.L2.LEC-04
N1.L3.PRE-05
N1.L3.LEC-07, 09

Direction of Friction
N2.L1.PRE-09, 10
N2.L1.LEC-06, 07, 08
N2.L1.POST-01, 02

Inclined Planes
N2.L2.PRE-04
N2.L2.LEC-03, 04, 06
Week 6 CHW
Lab 5

Free response questions

5. (5 points) An elevator is travelling upwards and slowing down. A phone is kicked across the floor of the elevator so that it is given an initial speed, v_i, to the right. Eventually, due to friction between the phone and the ground, the phone comes to a stop. The coefficient of kinetic friction, μ_k, is 0.5.



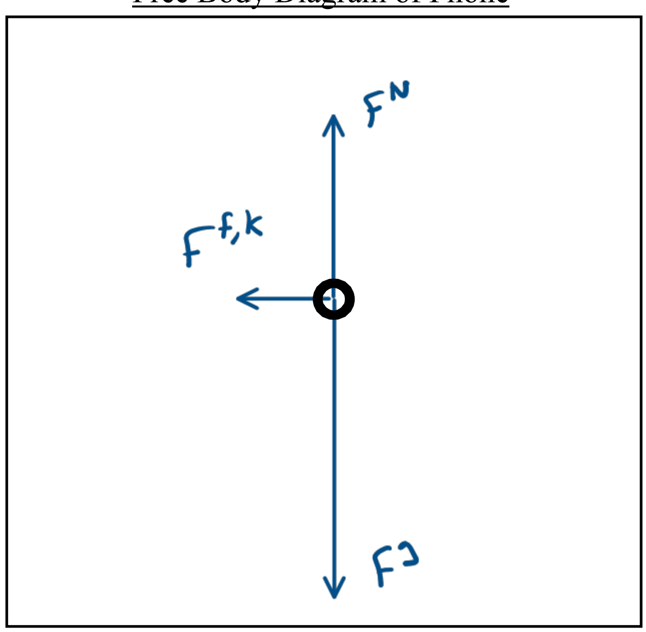
(a) Is the normal force from the elevator on the phone greater than, less than, or equal to the weight of the phone? Explain your reasoning using any combination of words, equations, diagrams, etc.

elevator is $v \uparrow$ $a \downarrow$ b/c it is slowing down. Phone is too.

$a \downarrow \Rightarrow \Sigma F \downarrow \Rightarrow$ F^N, $F^g = mg$ $\Rightarrow$ the normal force must be smaller than weight

(b) Draw a scaled free body diagram of the phone after it was kicked (while it is sliding across the floor) in the elevator

Free Body Diagram of Phone



$|F^N| < |F^g|$

$|F^{f,k}| = \frac{1}{2}|F^N|$

b/c $\mu_k = 0.5$

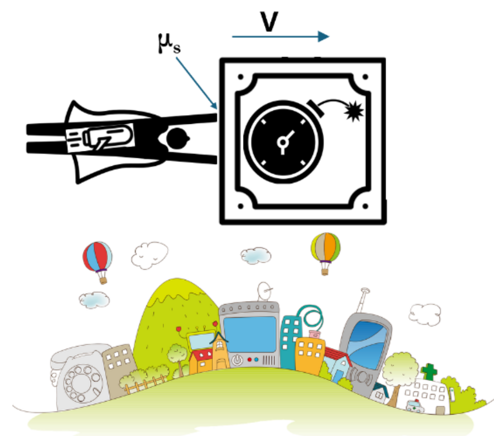
Concepts assessed and Related Questions

Force $\neq$ velocity
N1.L1.LEC-09, 10

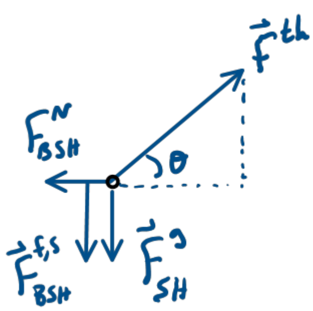
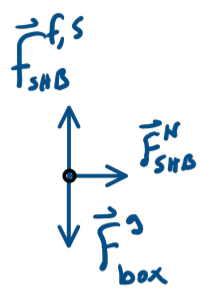
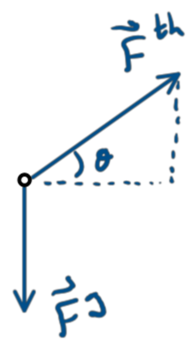
Free Body Diagrams
N1.L1.LEC-09, 10, 11
N1.L1.POST-01, 04
N1.L2 - all Qs

Rubric:
(a) - 0.5 pt
Explanation completeness, clarity, and physical correctness
(b) - 4.5 pts
Each force present, labled, and in correct direction
No additional forces present
Accuracy of force scaling
(F^N is smaller than F^g and $F^{f,k}$ is 1/2 the length of F^N)

6. (9 points) Superhuman is saving a town from a box bomb by pushing on it horizontally away from town while flying. He is pushing with a great enough force that static friction is large enough to prevent the box from sliding downward relative to his hands. Both Superhuman and the box are moving and accelerating only in the horizontal direction. This is possible because he has a jetpack that provides a thrust, $\mathbf{F}^{th}$, at an angle ($\boldsymbol{\theta}$) with respect to the horizontal. Assume the mass of Superhuman is the same as the box bomb.



(a) Draw a free-body diagram for (i) Superhuman, (ii) the box, and (iii) a system that includes both Superhuman and the box. Label each vector and scale them relative to each other.

<table>
<tr><th>Superhuman</th><th>Box</th><th>Superhuman + box system</th></tr>
<tr><td></td><td></td><td></td></tr>
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(b) Identify all Newton's 3rd law force pairs between Superhuman and the box.

$$F^N_{BSH} \longleftrightarrow F^N_{SHB}$$

$$F^{f,s}_{BSH} \longleftrightarrow F^{f,s}_{SHB}$$

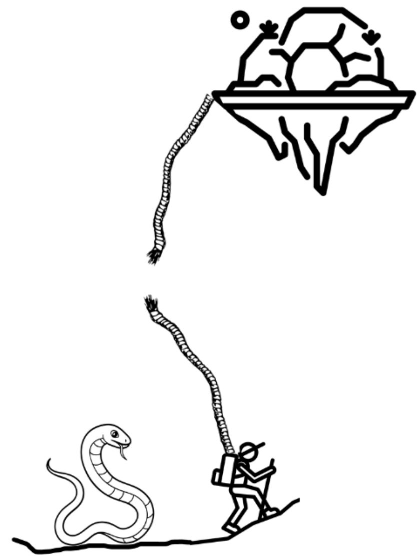
Rubric
Part (a) - 7.5 points total
  2.5 pts - FBD Superhuman
  2.5 pts - FBD Box
  2.5 pts - FBD Superhuman + box
Part (b) - 1.5 points total

Concepts assessed and Related Questions

Free Body Diagrams
N1.L1.LEC-09, 10, 11
N1.L1.POST-01
N1.L2.PRE-02
N1.L2.LEC-02, 03, 04

Static Friction
N2.L1.PRE-01, 06, 07
N2.L1.LEC-06
N2.L1.3-02, 03

7. (8 points) In a daring rescue, on Earth, an explorer is lifted vertically by a rope from a 100-m-deep cave filled with mutant snakes. If the max tension in the rope is 10% greater than the weight of the explorer, what is the minimum time they can be rescued from the cave?



FBD

Y

$$\Sigma F_y = m a_y$$

$$|F^T| - |F^g| = m a_y$$

$$(1.1)\cancel{m}g - \cancel{m}g = \cancel{m}a_y$$

$$(0.1)g = a_y$$

minimum time $\Rightarrow$ max tension

$\Rightarrow F^T = 110\% F^g$

$\Rightarrow F^T = (1.1)F^g$

Kinematics

$$\Delta y = \cancel{v_{iy}}^{\,0}\Delta t + \frac{1}{2}a_y \Delta t^2$$

$$\Delta y = \frac{1}{2}a_y \Delta t^2$$

$$\Delta t = \sqrt{\frac{2\Delta y}{a_y}} = \sqrt{\frac{2\Delta y}{(0.1)g}} = \sqrt{\frac{20(100m)}{(9.8m)}} = \boxed{14.3 \text{ sec}}$$

Rubric
1.5 pts - FBD, organization of information
0.5 pt - Knowing to do a force analysis
1.5 pts - Newton's 2nd Law equation application
1 pt - Tension = 1.1 mg
1 pt - kinematics analysis
1.5 pts - application of kinematic
0.5 pt - correct answer and units

Concepts assessed and Related Questions

Free Body Diagrams and Force Analysis
N1.L1, N1.L2, N1.L3

Tension, gravity, and acceleration
N1.L1.LEC-11
N1.L2.POST-01
N3.L1.PRE-04
N3.L1.LEC-06
N3.L1.POST-01
Week 5 Challenge Homework

Connecting Force Analysis and Kinematics
N1.L3.PRE-04
N1.L3.LEC-06, 07
N1.L3.POST-01
N2.L2.LEC-04
N2.L2.POST-01, 03

(Extra space if needed, indicate on original solution that some of your work is here)