Physics 114C
Autumn 2024

114C - DEPIES

Midterm 2
November 12th, 2024

Please use the boxes below to clearly print your name and UW NetID.
Please write within the boxes.

Printed Name	

first *last*

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I certify that the work I shall submit is my own creation, not copied from any source.

Signature ________________________________ **Seat Number** _________________

Clearly fill out this cover page and the top portion of the provided bubble sheet with the necessary information.

Do not open the exam until told to do so.
When prompted, clearly print the information required at the top of each page of this exam booklet.
You can remove the equation sheet(s). Otherwise, keep the exam booklet intact.
You will have 60 minutes to complete the examination.

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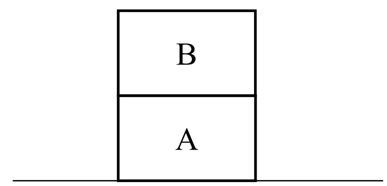
I. **Lecture Multiple Choice [60 pts]. Choose <u>only one</u> answer for each question and fill it out on your bubble sheet.**

1. [5 pts] A 1200-kg car accelerates at a steady rate from rest to 25 m/s in 4.0 s on a straight horizontal road over a distance of 50 m. Neglecting friction and air resistance, what is the net force acting on the car?

   A. 30000 N
   B. 15000 N
   C. 12000 N
   D. 7500 N
   E. 5000 N

2. [5 pts] Two blocks A and B are placed in a stack over a table, as shown at right. Which one of the following forces would NOT appear on the free-body diagram of block A?

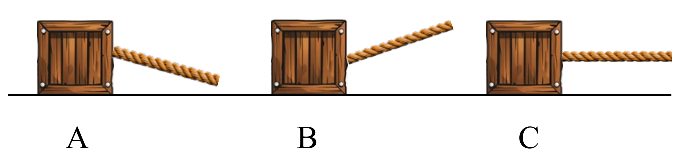


   A. The weight of block A.
   B. The weight of block B.
   C. The normal force by the table on A.
   D. The normal force by B on A.
   E. None of these

3. [5 pts] A person stands inside an elevator while the elevator is descending and slowing down. Is the normal force by the floor of the elevator onto the person greater than, less than or equal to the person's weight?

   A. Greater than
   B. Less than
   C. Equal to
   D. The answer depends on the value of the elevator's acceleration.
   E. None of the above.

4. [5 pts] Three identical crates A, B and C each of mass m are being pulled by ropes over flat horizontal ground, as shown at right. Choose the correct ranking of the normal forces by the ground (G) on the crates.



   A. $n_{GA} > n_{GC} > n_{GB} > mg$
   B. $n_{GA} > n_{GC} = mg > n_{GB}$
   C. $n_{GB} > n_{GC} = mg > n_{GA}$
   D. $n_{GA} = n_{GC} = n_{GB} = mg$
   E. $n_{GC} = mg > n_{GA} = n_{GB}$

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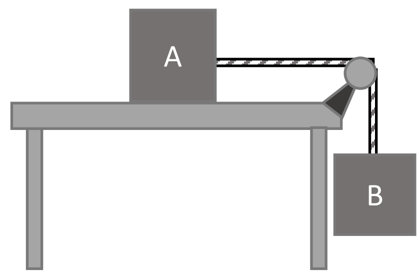
5. [5 pts] Consider crate C from the previous question where the rope is horizontal. The mass of the crate is 50 kg, the coefficients of static and kinetic friction with the ground are $\mu_s = 0.4$ and $\mu_k = 0.3$ and the tension in the rope is 250 N. What is the force of friction acting on the crate?
Hint: Is the applied tension big enough to overcome maximum static friction?

   A. 100 N
   B. 250 N
   C. 200 N
   D. 150 N
   E. 50 N

Use the following situation to answer the next two questions.

Two blocks, A and B, are connected by a massless inextensible string running over a frictionless pully with block A placed on the table, and block B hanging over the edge of a table.



6. [5 pts] The surface of the table is rough so that the force of static friction prevents block A from moving. Is the magnitude of that force of friction by the table on block A greater than, less than or equal to the weight of the hanging block B?

   A. Greater than
   B. Less than
   C. Equal to
   D. Not possible to answer without knowing the masses.

7. [5 pts] We now repeat the same experiment in the previous question but replace the rough table with a frictionless one. Choose the expression representing Newton's second law applied to block B, where T is the magnitude of tension in the string and a is the magnitude of acceleration of the system.

   A. $T = m_B a$
   B. $T = m_A g + m_B g$
   C. $m_B g - T = m_B a$
   D. $m_B g + T = m_B a$
   E. $m_B a = m_B g$

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Use the following situation to answer the next two questions.
A microscopic spherical particle of smoke drops from rest to the ground through air.

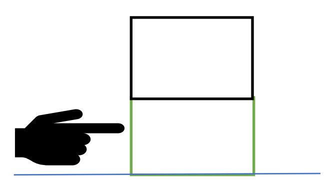
8. [5 pts] Which one of the following correctly describes this problem? Do NOT neglect air resistance.

   A. This is a high Reynold's number problem where inertial forces dominate viscous forces.
   B. The particle accelerates for a long time before reaching its terminal speed.
   C. The particle moves at free-fall acceleration throughout its drop.
   D. The drag force on the particle is proportional to the density of air.
   E. The drag force acting on the particle is proportional with the particle's speed.

9. [5 pts] The smoke particle has a radius of $2.0 \times 10^{-8}m$ and a mass of $5.0 \times 10^{-16}kg$. At what terminal speed does that particle fall through air?
   You may need some of these values: density of air is $\rho = 1.2\ \mathrm{kg/m^3}$, viscosity of air is $\eta = 1.8 \times 10^{-5}\mathrm{Pa \cdot s}$, drag coefficient for a spherical object is $C_D = 0.5$.

   A. $7.2 \times 10^{-4}\mathrm{m/s}$
   B. $4.8 \times 10^{-3}\mathrm{m/s}$
   C. $3.1 \times 10^{-4}\mathrm{m/s}$
   D. $5.5 \times 10^{-3}\mathrm{m/s}$
   E. $3.6\ \mathrm{m/s}$

10. [5 pts] Two blocks are stacked on top of each other and placed on the floor. There is friction between the blocks and friction with the floor. The bottom block is pushed with a force and accelerates, as does the top block with it. What force is accelerating the top block? Both blocks move together.



   A. The force from the hand acts on both the top and bottom blocks
   B. the normal force from the bottom block acts on the top block and pushes it forward
   C. kinetic friction from the bottom block acts on the top block and pushes it forward
   D. static friction from the bottom block acts on the top block and pushes it forward
   E. none of these properly describe the situation.

11. [5 pts] Two cars take a turn on the freeway at constant speed. Car A is on the inside and car B is on the outside of the turn, and they both complete the turn in the same time. Which car had the greatest tangential speed?
    A. Same speed
    B. Car A was faster
    C. Car B was faster
    D. would need to the actual radii to make a comparison

12. [5 pts] You round a turn in your car with a radius of 15.0 m moving with a speed of 7.5 m/s on flat ground. What force is required to allow you to complete the turn? The car's mass is 1,200 kg.
    A. 4.5 kN
    B. 9 kN
    C. 700 N
    D. 450 N
    E. Not enough information

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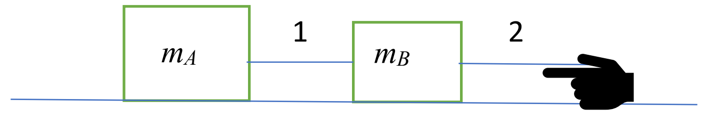
II. Free response questions 13-16 [20 pts]: Please show work or explain reasoning for full credit.

Two blocks are connected by a massless string and pulled by another massless string as shown. A hand pulls on the string to the right. There is no friction or air resistance.



13. [8 pts] Draw free body diagrams (FBD) for mass A and mass B. Use notation from the text and class.

FBD block A

FBD block B

14. [3 pts] Draw the direction of the net force on A and B in the boxes below:

F net on A

F net on B

15. [3 pts] Draw the direction of the acceleration of A and B in the boxes below:

acceleration of A

acceleration of B

16. [6 pts] It is found that the mass is moving to the *left* and slowing down. If the acceleration is 2.7 m/s^2 what is the tension in string 1 and string 2? Let m_B=1.6 kg and m_A=1.5 m_B.

T_1= T_2=

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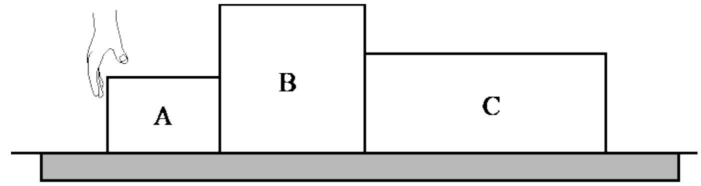
III. Tutorial Free Response [20 pts] Explain your answer where required.

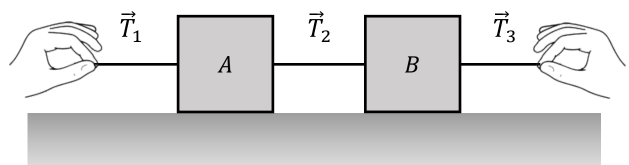
A hand pushes three blocks with masses $m_A < m_B < m_C$ over a rough table. The blocks move at constant velocity.



17. [4 pts] Is the net force on block A greater than, less than or equal to the net force on block C? Explain briefly.

18. [6 pts] Consider the following statement: "The force by block B on block C is greater than the force by block A on block B". Do you agree or disagree? Explain your answer briefly.

19. [4 pts] Two identical blocks, A and B, each of mass m are connected via a massless string. The blocks are on a frictionless horizontal surface. Two hands pull on two other massless strings connected to the two blocks, as shown.
If the two-block system is accelerating to the left, rank the magnitudes of the tension forces $\vec{T}_1$, $\vec{T}_2$ and $\vec{T}_3$ from the smallest to greatest. No need to provide explanation.



Answer:

20. [6 pts] Suppose now the massless string connecting the two blocks is replaced by a rope of mass $m_R > 0$. If the hands are still pulling on the other strings causing the two-block system to accelerate to the left, is the horizontal component of the tension force by block B on the rope *greater than*, *less than*, or *equal to* the horizontal component of the tension force by block A on the rope? Explain your answer briefly.

Physics 114 Midterm 2 Exam Equation Sheet

Constants and Conversions

Free-fall acceleration $g = 9.80\ \mathrm{m/s^2}$

Newton $1\ \mathrm{N} = 1\ \mathrm{kg\ m/s^2}$

Mathematics, Scaling and Vectors

Logarithm $b = a^x \leftrightarrow \log_a(b) = x$

$\log(ab) = \log(a) + log(b)$

$\log Ax^n = n \log x + \log A$

Volume of a sphere $V = \frac{4}{3}\pi r^3$

Surface area of a sphere $A = 4\pi r^2$

Volume of a cylinder $V = \pi r^2 l$

Surface area of a cylinder $A = 2\pi r^2 + 2\pi rl$

Mass density $\rho = m/V$

Area of trapezoid $A = \frac{1}{2}(b_1 + b_2)h$

x-component of a vector $\vec{A}$ $A_x = A\cos\theta$ (rel. to x– axis)

y-component of a vector $\vec{A}$ $A_y = A\sin\theta$ (rel. to x– axis)

Magnitude of vector $\vec{A}$ $A = \sqrt{A_x^2 + A_y^2}$

Direction of $\vec{A}$ relative to x-axis $\theta = \tan^{-1}(A_y/A_x)$

Addition of two vectors If $\vec{C} = \vec{A} + \vec{B}$, then

$C_x = A_x + B_x$

$C_y = A_y + B_y$

Kinematics

Displacement $\Delta x = x_f - x_i$

Average Velocity $v_{avg} = \frac{\Delta x}{\Delta t}$

Instantaneous Velocity $v_{inst.} = \lim_{\Delta t \to 0} \frac{\Delta x}{\Delta t}$

Average Acceleration $a_{avg} = \frac{\Delta v}{\Delta t}$

Kinematics Continued

Instantaneous Acceleration $a_{inst.} = \lim_{\Delta t \to 0} \frac{\Delta v}{\Delta t}$

Uniform motion $(v_x)_\mathrm{f} = (v_x)_\mathrm{i} = \text{constant}$

Position in uniform motion $x_f = x_i + (v_x)_i \Delta t$

Constant acceleration:

$(v_x)_f = (v_x)_i + a_x \Delta t$

$x_f = x_i + (v_x)_i \Delta t + \frac{1}{2} a_x (\Delta t)^2$

$(v_x)_f^2 = (v_x)_i^2 + 2a_x \Delta x$

Forces

Newton's second law $\vec{F}_\mathrm{net} = \sum \vec{F} = m\vec{a}$

Newton's second law Component form $F_{\mathrm{net},x} = \sum F_x = ma_x$

$F_{\mathrm{net},y} = \sum F_y = ma_y$

Newton's Third Law $\vec{F}_\text{A on B} = -\vec{F}_\text{B on A}$

Weight $w = mg$

Apparent weight w_app = magnitude of supporting forces

Kinetic friction $f_k = \mu_k n$

Static friction $0 \le f_s \le \mu_s n$

Reynolds number $Re = \rho v l/\eta$

Drag (high Reynolds number) $D = \frac{1}{2} C_D \rho A v^2$

Drag (low Reynolds number) $D = 6\pi\eta r v$

Circular Motion

Centripetal acceleration $a = \frac{v^2}{r} = \omega^2 r$

Frequency $f = \frac{1}{T} = \frac{v}{2\pi r}$