Physics 114 A
Winter 2026

114A - DEPIES

Midterm 1
February 3rd, 2026

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

Printed Name	

first *last*

UW Net ID	

(part before @uw.edu)

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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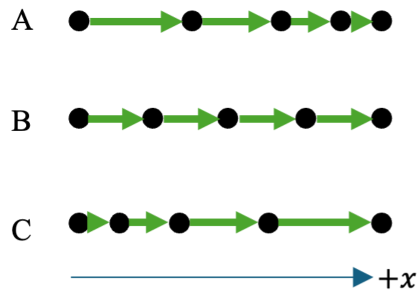
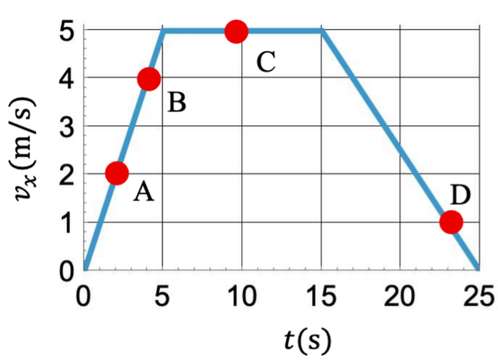
I. **Multiple Choice** [5 pts each] Bubble in the most correct answer on your bubble sheet and circle the correct answer here.

1. [5 pts] The motion diagrams shown at right are for three objects. For which object(s) is the acceleration zero?
   A. A only.
   B. B only.
   C. C only.
   D. A and B but not C.
   E. A and C but not B.



2. [5 pts] A runner travels around a circular track of circumference 400 meters. They do a single lap in 58 s. What is their average velocity?
   A. 0 m/s
   B. 3.5 m/s
   C. 6.1 m/s
   D. 32 m/s
   E. 45 m/s

Use the following situation to answer the next two questions:
The graph at right shows the plot of the velocity vs. time for a runner moving along the *x*-axis.



3. [5 pts] What is the distance they ran from the time of zero to C? Assume C is at 10 s.
   A. 130 m
   B. 62 m
   C. 54 m
   D. 38 m
   E. 72 m

4. [5 pts] What is the value of the acceleration at point C?
   A. 0 m/s^2
   B. –1.0 m/s^2
   C. 1.0 m/s^2
   D. 10 m/s^2
   E. –10 m/s^2

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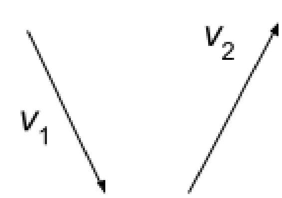
Use the following situation to answer the next two questions:
You toss a rock straight up. The rock reaches its highest point in 0.8 s. In what follows, neglect air resistance.

5. [5 pts] At what initial speed was the rock tossed?
   A. 5.2 m/s
   B. 3.7 m/s
   C. 1.6 m/s
   D. 7.8 m/s
   E. None of these are correct.

6. [5 pts] On the way back down, as the rock is falling to half the maximum height above the launch point, does it need more time, less time, or the same amount of time to travel the remaining half (closest to the hand) of the distance back to your hand?

   The first half of the trip is from the top to halfway. The question is about the lower half of the trip, from halfway back to the hand.
   A. More time.
   B. Less time.
   C. Same amount of time.
   D. The answer depends on the initial speed.
   E. Information is not enough to answer.

7. [5 pts] At an initial time $t = t_1$ an object has velocity $\vec{v}_1$. Later on at time $t = t_2$, the object's velocity is $\vec{v}_2$. The two vectors are shown at right. Which of the following arrows best describes the general direction of the average acceleration experienced by the object?
   A. ↘
   B. ↖
   C. ↓
   D. ↑
   E. ←



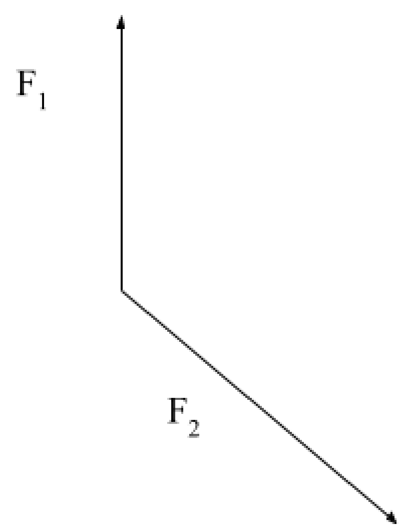
8. [5 pts] A ball is fired at an angle of 32 degrees above the horizontal. Ignore air resistance. What can you say about the speed (magnitude of the velocity) of the ball at the highest point in its trajectory?
   A. It is zero.
   B. It is the maximum speed the ball will have.
   C. It is the minimum speed the ball will have.
   D. It can be a maximum or minimum depending on the angle
   E. None of the above are true.

9. [5 pts] There is a box sitting on the bed of a truck. While driving the box suddenly moves towards the back of the truck. What can you say is true about the motion of the truck?
   I. The truck was initially at rest and then accelerated forward.
   II. The truck was already moving forward at constant speed and then sped up.
   III. The truck was already moving in reverse at constant speed and then sped up.
   A. (I) only.
   B. (II) only.
   C. (III) only.
   D. (I) and (II).
   E. (I), (II) and (III).

10. [5 pts] A ball is dropped from a tower in northern Italy. When it is freely falling towards the Earth what is the force the ball applies to the Earth?
   A. 0 N, since they are in free-fall it applies no force to the Earth.
   B. The force on the Earth from the ball is the same magnitude as the weight of the ball, due to Newton's 3rd law.
   C. The Earth's mass is so large it is a tiny value compared to the weight of the ball. So the force is approximately zero.
   D. It depends on the acceleration of the ball, due to Newton's 2nd law. If (and only if) they accelerate at $a =- g$ then they are equal and opposite.
   E. None of these are correct.

11. [5 pts] A force of 55 N acts on a ball, which accelerates at 5.5 m/s^2 in the same direction as the force. If the ball has a mass of 2.0 kg what is the magnitude of an additional force that must act on the ball?
    A. 0 N
    B. 11 N
    C. 23 N
    D. 44 N
    E. None of these are true.

12. [5 pts] Two forces act on a body as shown, what is the direction of the net force on the body?
    A. ↑
    B. ↓
    C. ↙
    D. ←
    E. →



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II. **Lecture Free Response** [20 pts total]: Show work and/or explain reasoning where indicated.

For problems 13-16 the following situation applies:
A ball is pushed off of a cliff with an initial velocity of 18 m/s horizontal to the ground below. There is no air resistance.

13. [2 pts] After the ball leaves the top of the cliff, what is its acceleration? Give both magnitude and direction.

Direction:	Magnitude:

14. [6 pts] It is found that the ball hits the ground in 1.8 seconds. How high above the ground was it? *Show work or explain reasoning* for full credit.

$h =$

15. [6 pts] How far from the edge of the cliff does the ball hit the ground? *Show work* or *explain reasoning* for full credit.

$x_f =$

16. [6 pts] What is the final speed of the ball right before it hits the ground? *Show work* or *explain reasoning* for full credit.

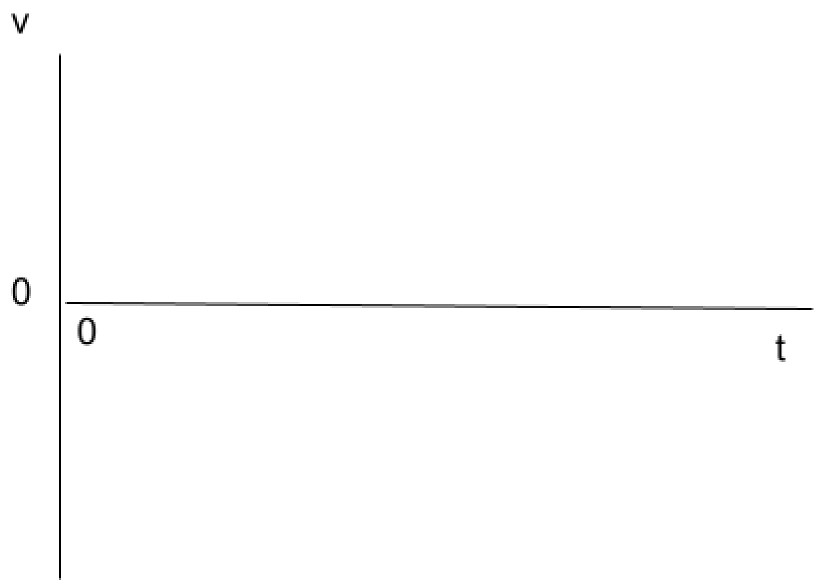
$v =$

III. **Tutorial Free Response** [20 pts total]: Problems 17-20. Show work and/or explain reasoning where indicated.

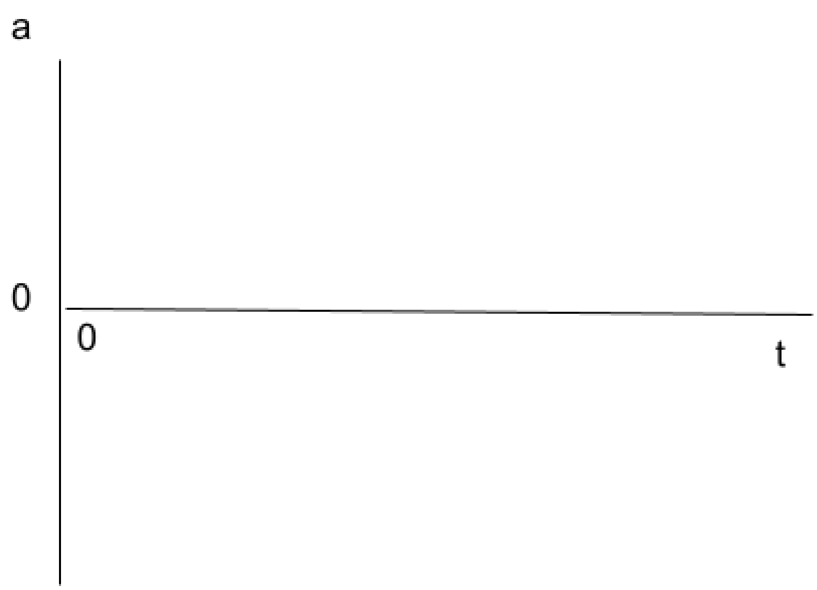
For 17. and 18., the following situation applies: you are moving away from a motion detector, and *slowing down*. You eventually turn around and speed up.

Assume away from the detector is the positive direction.

17. [5 pts] Draw the velocity vs time graph below for this motion.

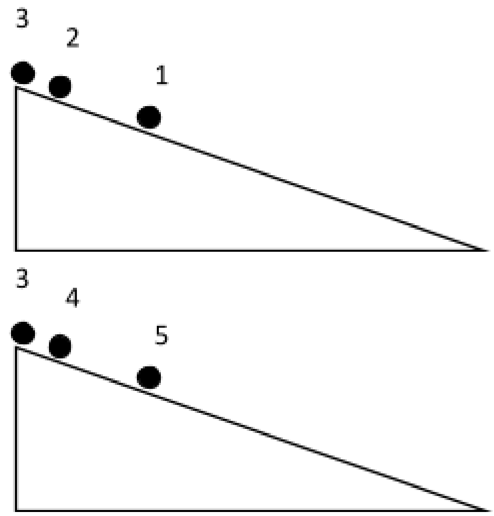


18. [5 pts] Draw the acceleration vs time graph for this motion.



19. [5 pts] The diagram at right shows a ball moving up a ramp and turning around at the top, each point taken at 1 s intervals. The diagrams are the same experiment, but the top is the ball moving up and the bottom is it moving down. Point 3 is the same for both.

What is the direction of the change in velocity from point 2 to 3, and then from point 3 to 4? What is the direction of the acceleration of the ball at point 3? Explain the acceleration direction for full credit.



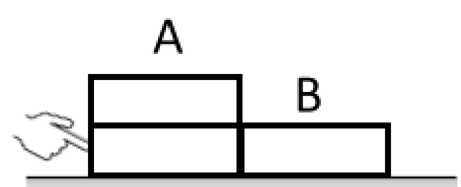
Δv_{23}

Δv_{34}

a_3

20. [5 pts] A set of three identical blocks are pushed as seen in the diagram below. There is friction between the ground and the blocks, and between the blocks. System A is two blocks and system B is one. The whole system moves to the right at a *constant speed*.

Is the net force on system A *greater than, less than, or equal to* the net force on system B? If it is zero state that explicitly. *Explain* your answer for full credit.



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Physics 114 Final 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	$A = 2\pi r^2 + 2\pi r l$
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	$(v_x)_\mathrm{f} = (v_x)_\mathrm{i} = \mathrm{constant}$
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	$\vec{F}_{\mathrm{A\ on\ B}} = -\vec{F}_{\mathrm{B\ on\ A}}$
Weight	$w = mg$
Apparent weight	$w_{\mathrm{app}} = \mathrm{magnitude\ of\ supporting\ forces}$
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	$f = \frac{1}{T} = \frac{v}{2\pi r}$

Physics 114 Final Exam Equation Sheet

Rotational Motion

Angular position	$\theta_{radians} = \frac{s}{r}$
Angular displacement	$\Delta\theta = \theta_f - \theta_i$
Average angular velocity	$\omega_{avg} = \frac{\Delta\theta}{\Delta t}$
Instantaneous angular velocity	$\omega_{inst.} = \lim_{\Delta t \to 0} \frac{\Delta\theta}{\Delta t}$
Average angular acceleration	$\alpha_{avg} = \frac{\Delta\omega}{\Delta t}$
Instantaneous angular acceleration	$\alpha_{inst.} = \lim_{\Delta t \to 0} \frac{\Delta\omega}{\Delta t}$
Period of uniform rotation	$T = \frac{2\pi}{\omega}$
Linear speed	$v = r\omega$
Tangential acceleration	$a_t = r\alpha$
Torque	$\tau = rF_\perp = r_\perp F = rFsin\theta$
Center of gravity	$x_{cg} = \frac{m_1x_1 + m_2x_2 + \cdots}{m_1 + m_2 + \cdots}$

Moment of inertia

Particles	$I = \sum m_i r_i^2$
Rod or plane (about center)	$I = \frac{1}{12}ML^2$
Rod or plane (about end)	$I = \frac{1}{3}ML^2$
Newton's 2nd law for rotation	$\alpha = \frac{\tau_{net}}{I}$

Stability and Elasticity

Critical angle	$\theta_c = tan^{-1}\left(\frac{(1/2)t}{h}\right)$
Hooke's Law	$\left(F_{sp}\right)_x = -k\Delta x$
Young's module	$\left(\frac{F}{A}\right) = Y\left(\frac{\Delta L}{L}\right)$
Tensile strength	$Tensile\ Strength = \frac{F_{max}}{A}$

Impulse and Momentum

Impulse	$\vec{J} = \vec{F}_{avg}\Delta t$
Momentum	$\vec{p} = m\vec{v}$
Impulse-momentum theorem	$\vec{J} = \vec{p}_f - \vec{p}_i = \Delta\vec{p}$
Total momentum	$\vec{p}_{total} = \vec{p}_1 + \vec{p}_2 + \vec{p}_3 + \cdots$
Conservation of momentum	$\vec{p}_f = \vec{p}_i$

Work and Energy

Work-energy equation	$W = \Delta E$
Work done by constant force	$W = F_\parallel d = Fdcos\theta$
Kinetic Energy	$K = \frac{1}{2}mv^2$
Rotational kinetic energy	$K = \frac{1}{2}I\omega^2$
Gravitational potential energy	$U_g = mgy$
Elastic potential energy	$U_s = \frac{1}{2}kx^2$
Thermal energy	$\Delta E_{th} = f_k\Delta x$
Elastic Collisions	$(v_{1x})_f = \frac{m_1 - m_2}{m_1 + m_2}(v_{1x})_i$ $(v_{2x})_f = \frac{2m_1}{m_1 + m_2}(v_{1x})_i$
Power	$P = \frac{\Delta E}{\Delta t} = \frac{W}{\Delta t} = Fv$