Physics 114 A
Spring 2025

114A - AL-BINNI

Midterm 1
April 29th, 2025

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	

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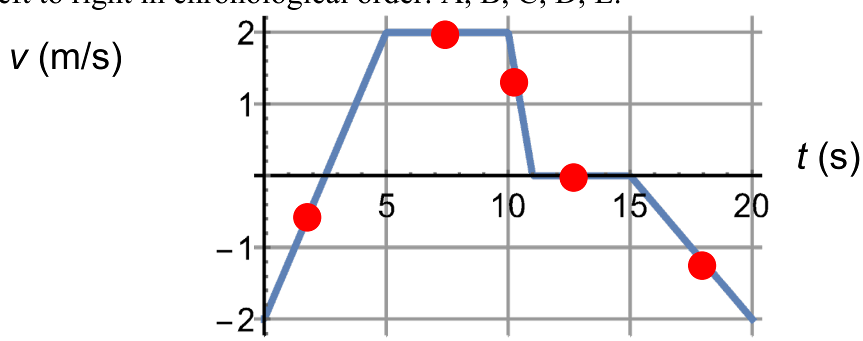
I. **Multiple Choice** [5 pts each] Bubble in the most correct answer on your bubble sheet and circle the correct answer here.

1. [5 pts] A jogger runs along a straight line over level ground a distance of 5.0 km and then turns back and jogs to the starting point. This round trip took 1.0 hour. Which one of the following statements is true about this jogger's average speed (distance over time) and average velocity (displacement over time)?
   A. The average speed is 10 km/h, but there is not enough information to find the average velocity.
   B. The average speed is 5.0 km/h and the average velocity is 0.0 km/h.
   C. The average speed is 10 km/h and the average velocity is 0.0 km/h.
   D. The average speed is 5.0 km/h, but there is not enough information to find the average velocity.
   E. Both the average speed and the average velocity are 10 km/h.

Use the following situation to answer the next three questions:
The velocity of an object moving along the x-direction is recorded in the graph shown at right. The points are ordered from left to right in chronological order: A, B, C, D, E.



2. [5 pts] Where is the object moving left and speeding up?
   A. At point A
   B. At point B
   C. At point C
   D. At point D
   E. At point E

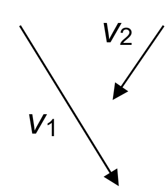
3. [5 pts] At $t = 0\ s$ the object is located at $x = -6.0\ m$. Where is it located at $t = 10\ s$?
   A. $x = 16\ m$
   B. $x = 4.0\ m$
   C. $x = -16\ m$
   D. $x = -4.0\ m$
   E. $x = 2.0\ m$

4. [5 pts] Rank the <u>**magnitudes**</u> of acceleration at the points shown.
   A. $a_B = a_D < a_E < a_A < a_C$
   B. $a_C < a_E < a_B = a_D < a_A$
   C. $a_E < a_A < a_D < a_C < a_B$
   D. $a_A < a_D < a_B < a_C < a_E$
   E. $a_D = a_B < a_A < a_C < a_E$

5. [5 pts] You are riding in the basket of a hot air balloon rising at a constant speed of 2.5 m/s straight up. You drop a tiny pebble, and it takes 3.8 seconds for it to hit the ground. At what height above ground did you release the pebble?
   A. 80 m
   B. 71 m
   C. 61 m
   D. 29 m
   E. 9.5 m

6. [5 pts] How fast is the pebble in the previous question moving right before it hits the ground?
   A. 35 m/s
   B. 40 m/s
   C. 0 m/s
   D. 2.5 m/s
   E. 17 m/s

7. [5 pts] At 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] Two projectiles A and B, are launched with the same initial speed v_i but at different launch angles θ_A and θ_B such that $\theta_A > \theta_B > 0$. Which one of the following statements is true?
   A. At maximum height projectile A is moving faster than projectile B.
   B. Both projectiles stand still at their respective maximum height.
   C. The two projectiles reach the same maximum height.
   D. Projectile A reaches a maximum height greater than that reached by projectile B.
   E. None of the above is true.

9. [5 pts] For the situation above, assume $v_i = 4.2\ m/s$ and $\theta_A = 33°$. If the projectile lands 1.6 m away horizontally at the same height it was launched, what is its total flight time, neglecting air resistance?
   A. 0.22 s
   B. 0.38 s
   C. 0.46 s
   D. 0.70 s
   E. 0.91 s

10. [5 pts] A cup is at rest on the floor of a bus. All of a sudden, the cup slides towards the rear of the bus. According to Newton's first law, which of the following statements could describe the motion of the bus? Neglect friction and assume the bus is moving on a horizontal road.
    I. The bus was initially at rest and then accelerated forward.
    II. The bus was already moving forward at constant speed and then sped up
    III. The bus was moving in reverse at constant speed and then slowed down.
    A. (I) only.
    B. (II) only.
    C. (III) only.
    D. (I) and (II).
    E. (I), (II) and (III).

11. [5 pts] A person has a mass of 60 kg, and jumps from an airplane to parachute to the ground. What is the *force the person applies to the earth* as they fall, before they open their parachute?
    A. 0 N, since they are in free-fall they apply no force to the earth.
    B. The earth's mass is so large it is a tiny value compared to the weight of the person. You can find it via the ratio of the masses of the person and the earth.
    C. It depends on the acceleration of the person, due to Newton's 2nd law. If they accelerate at $a = -g$ then they are equal and opposite.
    D. The force on the earth from the person is the same magnitude as the weight of the person, due to Newton's 3rd law.
    E. None of these are correct.

12. [5 pts] A person of mass *m* stands in an elevator that is moving down, and speeding up. Which of the following could describe the normal force on the person from the elevator? Assume the value of the acceleration *a* in the formulae below is the magnitude of the acceleration, and so is a positive number.
    A. $n = mg$
    B. $n = mg - ma$
    C. $n = -mg - ma$
    D. $n = ma$.
    E. None of these could be the normal force

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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 water balloon is tossed from ground level with an initial velocity of 8.5 m/s at an angle of 30 degrees above the horizontal. There is no air resistance.

13. [4 pts] *Describe* the acceleration of the balloon as it is in flight, both magnitude and direction.

14. [5 pts] How long does it take the balloon to reach its highest point? *Show work* for full credit.

t =

15. [5 pts] What is the magnitude of the velocity of the balloon at its highest point? If it is zero state that explicitly. *Show work* or *explain reasoning* for full credit.

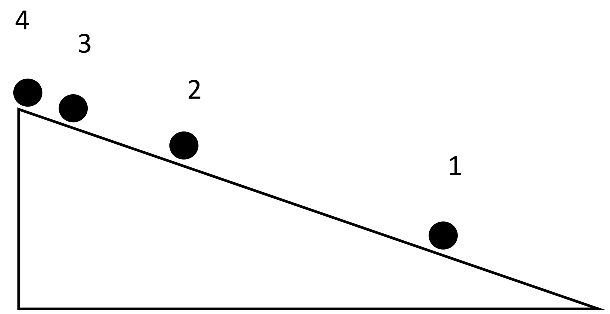
v =

16. [6 pts] If the intended target is 3.2 m away and is 1.5 m tall, will the balloon hit any part of the target? *Show work* for full credit.

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

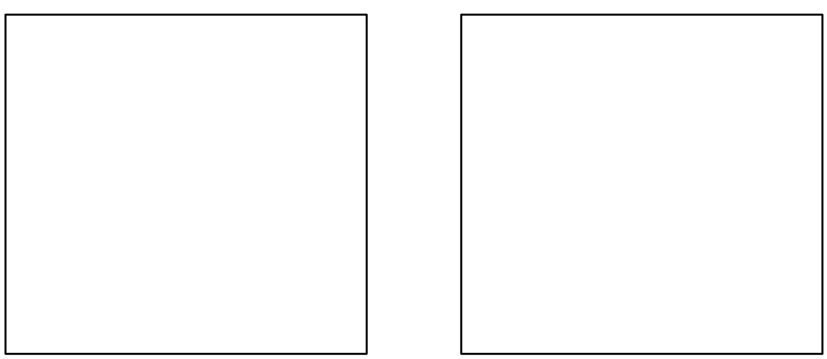
For 17. and 18. use the diagram below. The motion diagram below shows a ball moving up a ramp, and the time interval is the same between each point. It is at rest at point 4.

17. [5 pts] Indicate which point on the chart has the smallest acceleration. If they are all the same, write that down explicitly. *Explain* your reasoning.

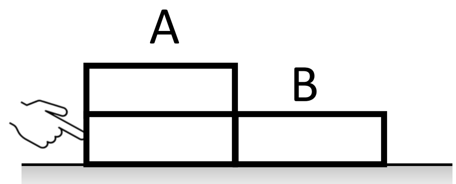


18. [5 pts] In the box below, draw the direction of the change in velocity between 1 and 2, that is Δv_{12}. In the next box draw the direction of the acceleration between 1 and 2, a_{12}. *Explain* your reasoning.

Δv_{12} a_{12}

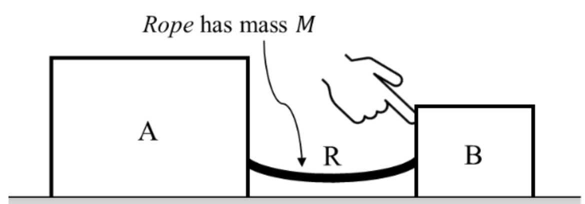


19. [5 pts] A set of identical blocks are pushed as seen in the diagram below. There is friction between the ground and the blocks, and between the blocks. The system moves to the right at a constant speed.



Does the force of the hand act on system B? If not the hand, then what acts on B? *Explain* your answer for full credit.

20. [5 pts] A hand is pushing on block B in the system below, where there is no friction. Note the rope has a mass of *M*. The system has been pushed for some time and is moving to the right.



Assume that mass A is greater than mass B which is greater than the mass of the rope.

Which is greater, the *force of the hand* on B, or the *force of the rope* on A? If there is no way to tell, state so 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	$P = \frac{\Delta E}{\Delta t} = \frac{W}{\Delta t} = Fv$