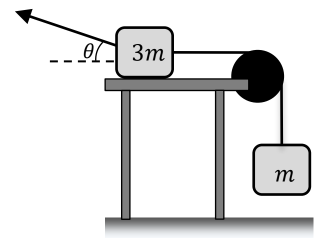
161 Fall 2025 Test 2A Once the exam has officially started, remove the top sheet. The remaining sheets comprise your exam. It is each student's individual responsibility to ensure the instructor has received her or his completed exam. Any exams not received by the instructor earn zero points. Smart watches, phones, or other devices (except scientific calculators) are not permitted during the exam.

$V_{sphere} = \frac{4}{3}\pi R^3$	$V_{box} = LWH$	$V_{cyl} = \pi R^2 H$	$\rho = \frac{M}{V}$
$A_{sphere} = 4\pi R^2$	$V = (A_{base}) \times (height)$	$A_{circle} = \pi R^2$	$x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$
$C = 2\pi R$	$A_{rect} = LW$	$A_{CylSide} = 2\pi RH$	
$160\underline{9}\ \text{m} = 1\ \text{mi}$	$12\ \text{in} = 1\ \text{ft}$	$60\ \text{s} = 1\ \text{min}$	$1000\ \text{g} = 1\ \text{kg}$
$2.54\ \text{cm} = 1\ \text{in}$	$1\ \text{cc} = 1\ \text{cm}^3 = 1\ \text{mL}$	$60\ \text{min} = 1\ \text{hr}$	$100\ \text{cm} = 1\ \text{m}$
$1\ \text{cm} = 10\ \text{mm}$	$1\ \text{yard} = 3\ \text{ft}$	$3600\ \text{s} = 1\ \text{hr}$	$1\ \text{km} = 1000\ \text{m}$
$1\ \text{furlong} = 220\ \text{yards}$	$528\underline{0}\ \text{ft} = 1\ \text{mi}$	$24\ \text{hrs} = 1\ \text{day}$	$1\ \text{rev} = 2\pi\ \text{rad} = 360°$
$g = 9.8\ \frac{\text{m}}{\text{s}^2}$	$G = 6.67 \times 10^{-11} \frac{\text{N}\cdot\text{m}^2}{\text{kg}^2}$	$P_0 = 1.0 \times 10^5\ \text{Pa}$	$1\ \text{eV} = 1.60\underline{2} \times 10^{-19}\ \text{J}$
$1\ \text{N} = 1 \frac{\text{kg}\cdot\text{m}}{\text{s}^2}$	$1\ \text{J} = 1\ \text{N}\cdot\text{m}$	$1\ \text{Pa} = 1\ \frac{\text{N}}{\text{m}^2}$	$m_e = 9.11 \times 10^{-31}\ \text{kg}$
$x_f = x_i + v_{ix}t + \frac{1}{2}a_x t^2$	$v_{fx}^2 = v_{ix}^2 + 2a_x(\Delta x)$	$v_{fx} = v_{ix} + a_x t$	$r = \sqrt{x^2 + y^2}$
$\vec{A} \cdot \vec{B} = AB\cos\theta_{AB}$	$\lVert \vec{A} \times \vec{B} \rVert = AB\sin\theta_{AB}$	$\sin(A \pm B)$ $= \sin A\cos B \pm \cos A \sin B$	$\cos(A \pm B) = \cos A\cos B$ $\mp \sin A \sin B$
$\vec{v}_{ae} + \vec{v}_{eb} = \vec{v}_{ab}$	$\hat{r} = \cos\theta\,\hat{\imath} + \sin\theta\,\hat{\jmath}$	$\hat{\theta} = -\sin\theta\,\hat{\imath} + \cos\theta\,\hat{\jmath}$	
$a_{tan} = r\alpha$	$a_c = \frac{v^2}{r} = r\omega^2$	$\vec{a} = a_r\hat{r} + a_{tan}\hat{\theta}$	$\vec{a} = a_c(-\hat{r}) + a_{tan}\hat{\theta}$
$\Sigma\vec{F} = m\vec{a}$	$f \le \mu n$	$\vec{F}_G = \frac{GmM}{r^2}(-\hat{r})$	$U_G = -\frac{GmM}{r}$
$TKE = \frac{1}{2}mv^2$	$RKE = \frac{1}{2}I\omega^2$	$U_S = SPE = \frac{1}{2}kx^2$	$U_G = GPE = mgh$
$E_i + W_{\substack{non-con \\ or\ ext}} = E_f$	$\Delta KE = W_{ext.\&\,non-con}$	$W = Fd\cos\theta = F_\parallel d$	$W = \int F_x dx$
$\Delta U = -W = -\int_i^f \vec{F}\cdot d\vec{s}$	$F_x = -\frac{d}{dx}U(x)$	$\mathcal{P}_{inst} = \frac{dE}{dt} = \vec{F}\cdot\vec{v}$	$\mathcal{P}_{avg} = \frac{\Delta E}{\Delta t} = \frac{Work}{time}$
$\vec{J} = \Delta\vec{p} = \vec{F}\Delta t$	$\vec{p} = m\vec{v}$	$x_{\text{CM}} = \frac{m_1x_1 + m_2x_2}{m_1 + m_2}$	$x_{\text{CM}} = \frac{\int x\,dm}{\int dm}$
$\vec{\tau} = \vec{r} \times \vec{F}$	$\Sigma\vec{\tau} = I\vec{\alpha}$	$L = I\omega = mvr_\perp$	$\mathcal{P}_{inst} = \vec{\tau}\cdot\vec{\omega}$
$s = r\Delta\theta$	$v = r\omega$	$a_{tan} = r\alpha$	$a_c = \frac{v^2}{r} = r\omega^2$
$I_{\parallel axis} = I_{\text{CM}} + md^2$	$I_{zz} = I_{xx} + I_{yy}$	$I = \int r^2 dm$	$\frac{F}{A} = E\frac{\Delta L}{L_0}$
$P = \frac{F}{A}$	$P_{gauge} = P_{abs} - P_{ambient}$	$B = \rho_f V_{disp} g$	$A_1v_1 = A_2v_2$
$P(h) = P_0 + \rho gh$	$P + \frac{1}{2}\rho v^2 + \rho gh = \text{constant}$	$R = \frac{\pi r^4 \Delta P}{8\eta L}$	$F = \eta A\frac{\Delta v_x}{\Delta y}$

Prefix	**Abbreviation**	**$10^?$**		**Prefix**	**Abbreviation**	**$10^?$**
Giga	G	10^9		milli	m	10^{-3}
Mega	M	10^6		micro	μ	10^{-6}
kilo	k	10^3		nano	n	10^{-9}
centi	c	10^{-2}		pico	p	10^{-12}
				femto	f	10^{-15}

Name:____

Coefficients of friction between $3m$ & the table are $\mu_s = 0.555$ & $\mu_k = 0.333$. A light, inextensible string connects $3m$ to m over a light pulley (negligible axle friction). A force is applied at fixed angle $\theta = 10.00°$.

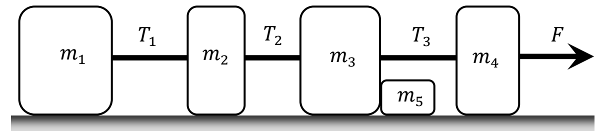


********1) What applied force magnitude is required to cause block m to accelerate upwards with rate $\frac{g}{5}$?

- Assume block $3m$ never loses contact with the surface.
- Answer as a decimal number with 3 sig figs times mg.
- Put your final answer in the box.

1	

A train of five blocks is pulled to the right across a level floor by a horizontal force of magnitude F. Block masses are indicated in the figure. Some blocks are connected by cables. **Assume each cable has negligible mass.** Tension magnitude of each cable is labeled in the figure by $T_1, T_2, \& T_3$. **Assume friction is negligible for all blocks <u>except</u> m_5.**



2a) Assuming $a_x > 0$, rank the tension magnitudes $T_1, T_2, \& T_3$ (from largest to smallest). Clearly indicate any ties.

2b) Which best describes the most general conditions under which $T_2 \approx T_1$? Circle the best answer.

When $m_1 = m_2$	When $m_3 = m_2$	This *always* occurs	This *never* occurs	When acceleration is positive	When acceleration is zero	Impossible to determine without more information	None of the other answers is correct

2c) Under what conditions does m_3 exert *more* force on m_5 than m_5 exerts on m_3? Circle the best answer.

When $m_3 < m_5$	When $m_3 = m_5$	When $m_3 > m_5$	This *always* occurs	This *never* occurs	When acceleration is positive	When acceleration is zero	Impossible to determine without more information	None of the other answers is correct

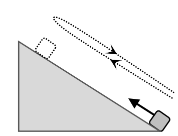
2d) Which best describes the work done <u>on block 5</u> by the normal force between blocks 3 & 5? Circle the best answer.

Positive	Negative	Zero	Impossible to determine without more info

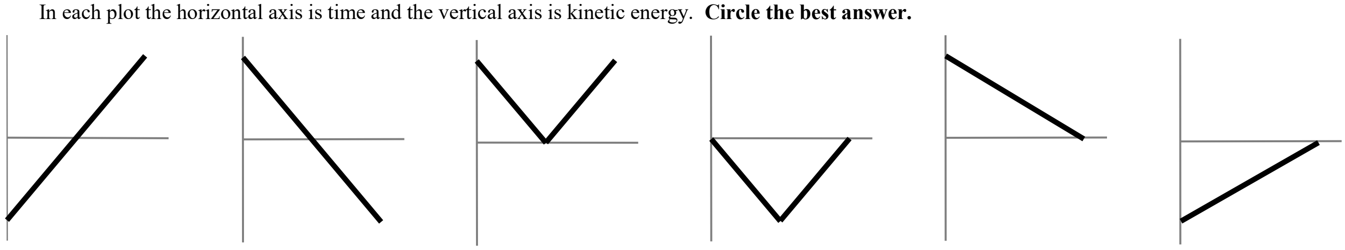
2e) Which best describes the work done by gravity <u>on block 5</u>? Circle the best answer.

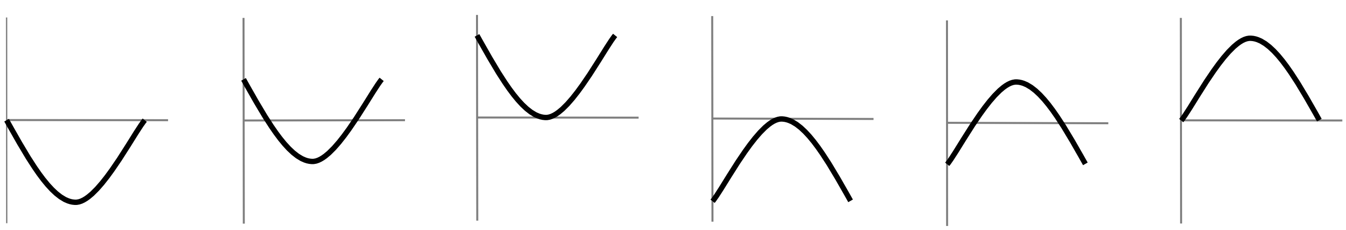
Positive	Negative	Zero	Impossible to determine without more info

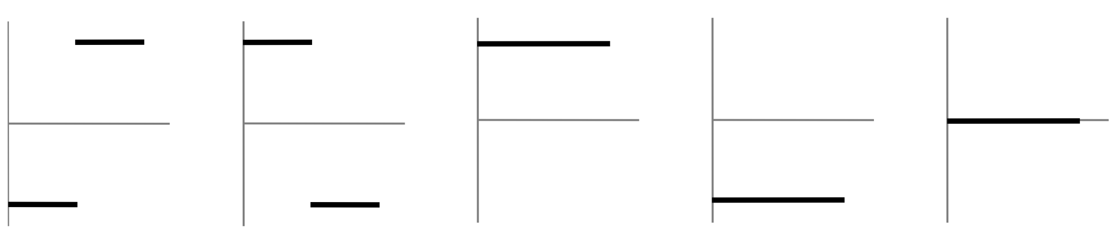
3) A block is kicked, causing it to slide on a frictionless incline. The block slides up the ramp some maximum distance before sliding back down to its original position. We are only concerned with the times just *after* the kick until the block returns to the bottom of the ramp (just *before* impact with the ground). **Which graph best represents *kinetic energy* of the block *as a function of time*?**



In each plot the horizontal axis is time and the vertical axis is kinetic energy. **Circle the best answer.**

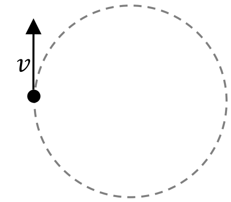






Impossible to determine which graph without more information

A person swings a ball of mass 222-grams on a string in a *vertical* circle of radius $0.555\ \mathrm{m}$. At the left side of the circle the ball is moving upwards with speed $4.44\,\frac{\mathrm{m}}{\mathrm{s}}$. Assume the magnitude of acceleration due to gravity is $9.80\,\frac{\mathrm{m}}{\mathrm{s}^2}$. Assume air resistance is negligible.



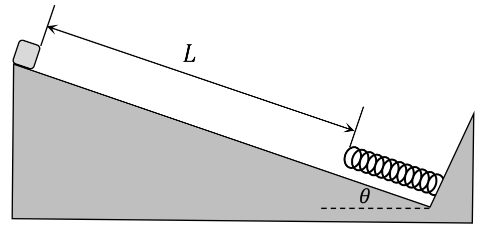
***4a) Determine the magnitude & direction of the ball's acceleration for the instant shown in the figure. Draw an arrow & label both the *magnitude* <u>and</u> *an angle* for ball's acceleration.

**4b) Determine speed of the ball *at the top of the loop*.

**4c) Determine tension (magnitude) in the string *at the top of the loop*.

4a Label mag & dir	
4b	
4c	

A block is released from rest. It slides distance L down a ramp of angle θ. At this point, the block impacts a light spring of constant k. The block then slides *additional* distance x as it compresses the spring. The block then reverses direction and moves towards the top of the ramp. Frictional coefficients between the block and the ramp are $\mu_s = \mu_k = \mu$. Air resistance is negligible. The system is near the surface of the earth.



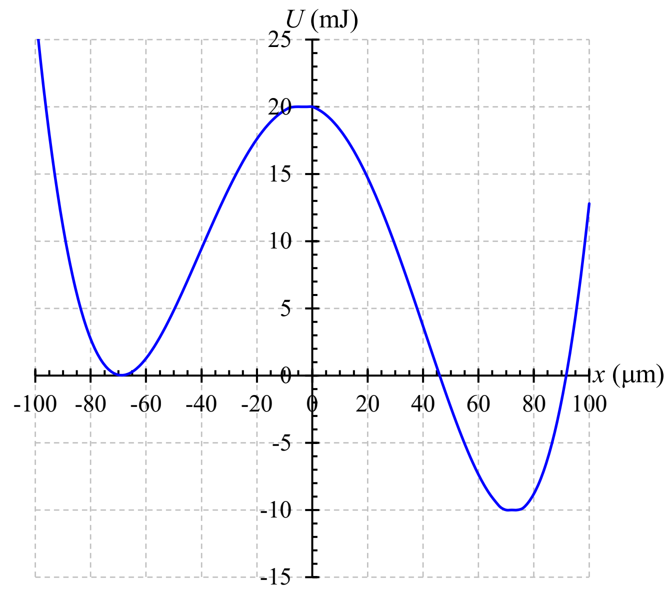
5a) Just after impact with the spring (as the block slows down), which of the following is true? Circle the best answer.

The spring exerts *more* force on the block than the block exerts on the spring	The spring exerts *less* force on the block than the block exerts on the spring	The spring exerts the same amount of force on the block as the block exerts on the spring	Impossible to determine without more information

*****5b) Determine mass of the block.

5b	

A particle of mass 3.33 pg (that's pico grams) moves along the x-axis subject to a single conservative force. A plot of potential energy versus position is shown for the particle.



6a) What *direction* does the particle accelerate when it is located at $x = -40.0$ μm? Circle the best answer.

Directly upwards	Some combo of up and left	Impossible to determine without more info
Directly downwards	Some combo of down and left	
Directly to the left	Some combo of up and right	None of the other answers is correct
Directly to the right	Some combo of down and right	

****6b) Estimate the particle's *acceleration magnitude* when it is located at $x = -40.0$ μm. **Answer in scientific notation.** Note: I randomly chose prefixes & values here so the number could be insanely large or small.

6b	

7) A 1250-kg rocket in deep space accelerates for 4.00 s. It accelerates from 0 to $20.0\,\frac{\mathrm{m}}{\mathrm{s}}$ in 1.500 s and then $20.0\,\frac{\mathrm{m}}{\mathrm{s}}$ to $30.0\,\frac{\mathrm{m}}{\mathrm{s}}$ during the remaining 2.50 s. Determine *average power output* of the rocket during these 4.00 s. **Answer in kW.

7	

A particle of mass m is subject to a single conservative force governed by

$$F_x = -\frac{k}{x^3}$$

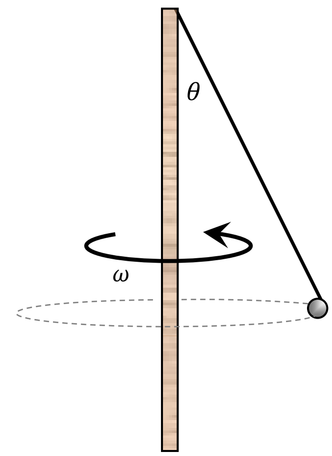
Here k is a positive constant and x is horizontal position.

8a) Determine the units assumed on the constant k.

***8b) Determine the *change* in potential energy going from $x = d$ to $x = 3d$.

8a	
8b	

A ball is attached to a pole with a string as shown. The string maintains angle θ from the pole as it rotates with constant rate ω. The magnitude of the acceleration due to gravity is g. Assume the radius of the ball is negligible compared to the length of the string.



*****9a) Determine the length of the string in terms of the listed variables.

Please notice the question at the bottom of the page!

9a	

**9b) Describe the reaction force associated with the weight of ball. Fill in the blanks below.

__________________ exerts a ____________________ force on _________________ directed ___________________.

Object exerting force | type of force (e.g. frictional, tension, etc) | object experiencing force | direction of force

Extra credit is often difficult and time consuming compared to the amount of points you earn.
Focus on solving the *regular* credit problems. Attempt this question if you have extra time at the end of the test.

A 1250-kg rocket in deep space accelerates for 4.00 s. It accelerates from 0 to $20.0\,\frac{\mathrm{m}}{\mathrm{s}}$ in 1.500 s and then $20.0\,\frac{\mathrm{m}}{\mathrm{s}}$ to $30.0\,\frac{\mathrm{m}}{\mathrm{s}}$ during the remaining 2.50 s.

***Extra Credit 1** – Determine power output *as a function of time* for time interval $t = 0$ to $t = 1.500$ s. This is somewhat straightforward.

***Extra Credit 2** – Determine power output *as a function of time* for time interval $t = 1.500$ s to $t = 4.00$ s. Do *not* reset time to zero for the second stage. This is significantly sneakier than EC1…

EC1	
EC2	

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