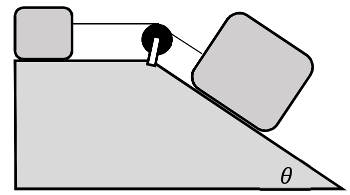
161 Spring 2022 Test 2C Once the exam has officially started, remove the top sheet. The remaining sheets comprise your exam. It is each student's individual responsibility to ensure the instructor has received her or his completed exam. Any exams not received by the instructor earn zero points. Smart watches, phones, or other devices (except scientific calculators) are not permitted during the exam.

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

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:____

For this problem you might want to skim the entire page before starting work so you know what I ultimately want you to figure out. Please let me know if you do scratch work elsewhere so I know to look for it.



A block of mass m rests on a horizontal surface with negligible friction. A block of mass $3m$ is initially held at rest on an incline of angle $\theta = 40.0°$. Friction exists between this block and the incline. The two blocks are connected by an ideal string (massless, inextensible) using an ideal pulley (massless, negligible axle friction). Upon being released from rest, the blocks accelerate together with rate $a = \frac{g}{6}$. Figure not to scale.

******1a) Draw FBDs for each block & list the force equations. Include a coordinate system to ensure credit.

FBD $\boldsymbol{3m}$ FBD $\boldsymbol{m}$

Force Equations $\boldsymbol{3m}$ Force Equations $\boldsymbol{m}$

1b) Determine the magnitude of the string tension.

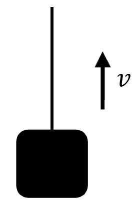
Answer as a decimal number with 3 sig figs times $\boldsymbol{mg}$.

1c) Determine the frictional coefficient between the incline and lower block as it slides.

Answer as a decimal number with 3 sig figs.

1b	
1c	

2a) A block of mass m is pulled upwards by a cable. At the instant shown, the block is moving upwards while slowing down. Which of the following best describes the relationship between cable tension and block weight? Circle the best answer.

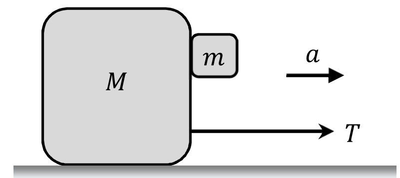


$T = mg$	$T > mg$	$T < mg$	Impossible to determine without more info

2b) Does tension do positive, negative, or zero work on the block as it moves upwards? Circle the best answer.

Positive work	Negative work	Zero work	Impossible to determine without more info

In an experiment, two blocks with masses M & m are pulled to the right across a level, frictionless surface. Friction is present between the two blocks. The blocks are pulled by the cable with tension T. At the instant shown in the figure, block m is on the verge of slipping.



3a) Does the normal force magnitude between the blocks (n_{12}) do positive, negative, or zero work on block M? Circle the best answer.

Positive work	Negative work	Zero work	Impossible to determine without more info

Now suppose the experiment is repeated, but this time the blocks are pulled with *twice* the tension. Describes what happens to each of the following by circling the best answer.

3b) How does the *new* normal force magnitude (n'_{12}) compare to the *old* normal force magnitude (n_{12})?

$n'_{12} = n_{12}$	$n'_{12} = 2n_{12}$	$n'_{12} = \frac{1}{2}n_{12}$	None of the previous answers is correct, but the answer can be determined	Impossible to determine without more info

3c) How does the *new* frictional force magnitude (f'_{12}) compare to the *old* frictional force magnitude (f_{12})?

$f'_{12} = f_{12}$	$f'_{12} = 2f_{12}$	$f'_{12} = \frac{1}{2}f_{12}$	None of the previous answers is correct, but the answer can be determined	Impossible to determine without more info

**3d) Consider an action-reaction pair. For this question, assume the *action* force is the weight of block m. Describe the *reaction* force by filling in the sentence below with:

- The object *exerting* the reaction force
- The *type* of force (normal, frictional, tension, gravitational, etc)
- The *direction* of the reaction force
- The object *experiencing* the reaction force

__________________ exerts a ___________________ force directed _______________ on __________________.

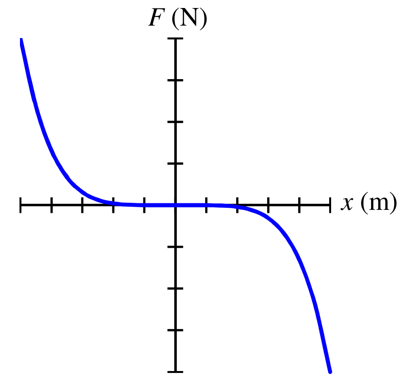
A particle of mass m experiences a single conservative force as it moves horizontally in 1-dimensional motion. Video analysis reveals the force is given by

$$F_x = -\alpha x^5$$

where α is a positive constant and x is horizontal position.

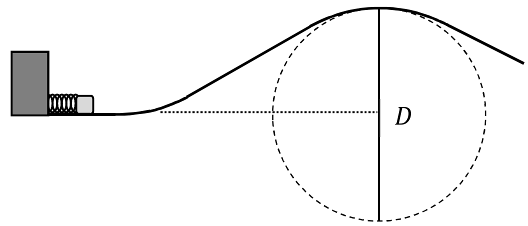
4a) Determine the units assumed for the constant α.

***4b) Determine an expression for potential energy (as a function of position) associated with this force. Assume zero potential energy at position $x = 0$.



4a	
4b	

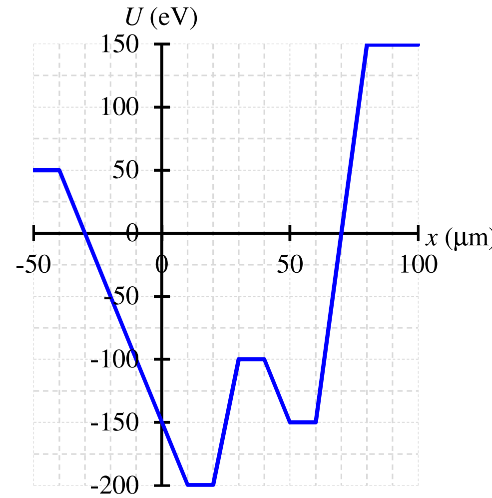
A block of negligible size and mass 0.222 kg is initially compressing a spring of constant $77.7\,\frac{\text{N}}{\text{m}}$. The block is released from rest and the spring causes the block to slide with negligible friction over the track shown. To be clear, the block is not attached to the spring. The block separates from the spring before reaching the incline (figure not to scale). The top of the hill can be modeled as a circular path of diameter 1.11 m. At the instant the block reaches the top of the hill, the normal force (magnitude) acting on the block is 33.3% of the block's weight. Assume $g = 9.8\,\frac{\text{m}}{\text{s}^2}$. To be clear, you may assume the block starts at the same height as the center of the circle.



***5a) Determine the speed of the block at the top of the hill.
***5b) Determine the initial compression distance of the spring.

5a	
5b	

A particle of mass 3.00×10^{-11} kg travels in 1D motion under the influence of a conservative force. This problem assumes the particle's motion was analyzed using a standard coordinate system of $+x$-direction to the right and $+y$-direction upwards. The plot of potential energy versus position for this force is shown at right. The particle is initially located at $x = -30.0$ μm and is released from rest.



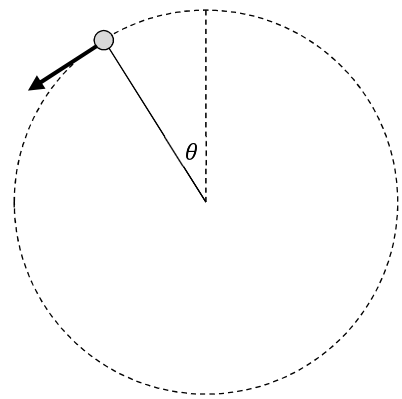
***6a) Determine the force *magnitude* acting on the particle at its initial position. Answer in units of N. Use scientific or engineering notation with appropriate prefix.

6a	

***6b) Briefly describe the motion of the particle after it is released from rest. In particular consider the following:

- Which way does the particle move initially (up, down, right left, or some combination?
- Will the particle travel past $x = -50$ μm or $x = +100$ μm?
  If so, explain how you know this to support your claim.
- Will the particle reverse direction at some point?
  If so, state the position at which the particle reverses direction to support your claim.
  Also explain how you know it reverses direction at this location.

A ball of mass 222 g swings in purely vertical circular motion on a massless, inextensible string. At the instant shown, the ball is moving with speed $5.55\frac{\text{m}}{\text{s}}$ at angle $\theta = 33.3°$. The tension in the string at this same instant is 9.99 N. The ball has negligible size compared to the radius of circular motion. Assume $g = 9.8\frac{\text{m}}{\text{s}^2}$.



****7a) Determine the radius of circular motion.
**7b) Determine the *magnitude* of tangential acceleration for the instant shown.
Notice 7c at the bottom of the page.

7a	
7b	

7c) Consider the time interval between the instant shown and the bottom of the circular motion. Which best describes the work done by string tension on the ball? Circle the best answer.

Positive work	Negative work	Zero work	Impossible to determine without more info

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