110 Fall 2023 Test 3A 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.

$V_{sphere} = \frac{4}{3}\pi R^3$	$V_{box} = LWH$	$V_{cyl} = \pi R^2 H$	$\rho = \frac{M}{V}$
$A_{sphere} = 4\pi R^2$	$V = (A_{base}) \times (height)$	$A_{circle} = \pi R^2$	$x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$
$C = 2\pi R$	$A_{rect} = LW$	$A_{CylSide} = 2\pi RH$	
$160\underline{9}\ \text{m} = 1\ \text{mi}$	$12\ \text{in} = 1\ \text{ft}$	$60\ \text{s} = 1\ \text{min}$	$1000\ \text{g} = 1\ \text{kg}$
$2.54\ \text{cm} = 1\ \text{in}$	$1\ \text{cc} = 1\ \text{cm}^3 = 1\ \text{mL}$	$60\ \text{min} = 1\ \text{hr}$	$100\ \text{cm} = 1\ \text{m}$
$1\ \text{cm} = 10\ \text{mm}$	$1\ \text{yard} = 3\ \text{ft}$	$3600\ \text{s} = 1\ \text{hr}$	$1\ \text{km} = 1000\ \text{m}$
$1\ \text{furlong} = 220\ \text{yards}$	$528\underline{0}\ \text{ft} = 1\ \text{mi}$	$24\ \text{hrs} = 1\ \text{day}$	$1\ \text{rev} = 2\pi\ \text{rad} = 360°$
$g = 9.8\ \frac{\text{m}}{\text{s}^2}$	$G = 6.67 \times 10^{-11} \frac{\text{N} \cdot \text{m}^2}{\text{kg}^2}$	$P_0 = 1.0 \times 10^5\ \text{Pa}$	$1\ \text{eV} = 1.60\underline{2} \times 10^{-19}\ \text{J}$
$1\ \text{N} = 1 \frac{\text{kg} \cdot \text{m}}{\text{s}^2}$	$1\ \text{J} = 1\ \text{N} \cdot \text{m}$	$1\ \text{Pa} = 1 \frac{\text{N}}{\text{m}^2}$	
$x_f = x_i + v_{ix}t + \frac{1}{2}a_x t^2$	$v_{fx}^2 = v_{ix}^2 + 2a_x(\Delta x)$	$v_{fx} = v_{ix} + a_x t$	$r = \sqrt{x^2 + y^2}$
$\vec{A} \cdot \vec{B} = AB\cos\theta_{AB}$	$\lVert \vec{A} \times \vec{B} \rVert = AB\sin\theta_{AB}$	$\sin(A \pm B)$ $= \sin A \cos B \pm \cos A \sin B$	$\cos(A \pm B)$ $= \cos A \cos B \mp \sin A \sin B$
$\vec{v}_{ae} + \vec{v}_{eb} = \vec{v}_{ab}$	$\hat{r} = \cos\theta\,\hat{\imath} + \sin\theta\,\hat{\jmath}$	$\hat{\theta} = -\sin\theta\,\hat{\imath} + \cos\theta\,\hat{\jmath}$	
$a_{tan} = r\alpha$	$a_c = \frac{v^2}{r} = r\omega^2$	$\vec{a} = a_r\hat{r} + a_{tan}\hat{\theta}$	$\vec{a} = a_c(-\hat{r}) + a_{tan}\hat{\theta}$
$\Sigma\vec{F} = m\vec{a}$	$f \le \mu n$		

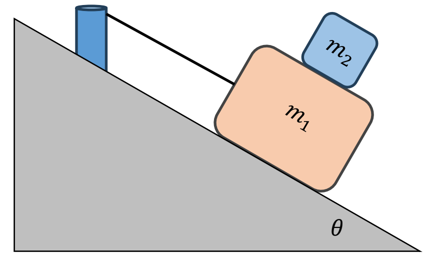
Prefix	Abbreviation	$10^?$		Prefix	Abbreviation	$10^?$
Giga	G	10^9		milli	m	10^{-3}
Mega	M	10^6		micro	μ	10^{-6}
kilo	k	10^3		nano	n	10^{-9}
centi	c	10^{-2}		pico	p	10^{-12}
				femto	f	10^{-15}

$$[\text{M}] = \text{units of mass} = \text{kg} \qquad [\text{L}^2] = \text{units of area} = \text{m}^2 \qquad [\text{T}] = \text{units of time} = \text{s} \qquad \left[\frac{\text{L}}{\text{T}^2}\right] = \text{units of acceleration} = \frac{\text{m}}{\text{s}^2}$$

$$[\text{L}] = \text{units of length} = \text{m} \qquad [\text{L}^3] = \text{units of volume} = \text{m}^3 \qquad \left[\frac{\text{L}}{\text{T}}\right] = \text{units of velocity} = \frac{\text{m}}{\text{s}} \qquad \left[\frac{\text{L} \cdot \text{M}}{\text{T}^2}\right] = \text{units of force} = \frac{\text{kg} \cdot \text{m}}{\text{s}^2} = \text{N}$$

Name:____

Two blocks are situated on an inclined plane of angle θ as shown (not to scale).
Frictional forces are negligible between m_1 and the incline.
Frictional coefficients between m_1 & m_2 are μ_s & μ_k.
An ideal string parallel to the plane prevents m_1 from sliding down the ramp.
At the instant shown, m_2 is sliding down the plane. Assume g is known.



********1a) Draw FBD's and write force equations for each block separately.
Include a coordinate system on each FBD or you may not receive credit.

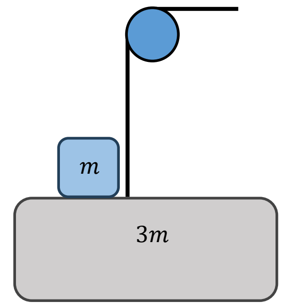
FBD for m_2	**FBD for m_1**
ΣF_x:	ΣF_x:
ΣF_y:	ΣF_y:

**1b) Determine acceleration magnitude of m_2. Answer as a simplified expression in terms of given quantities.

*1c) Determine string tension (magnitude). Answer as a simplified expression in terms of given quantities.

1b	
1c	

A block of mass $3m$ is supported by an ideal string (massless & inextensible).
The string runs over a pulley and a human holds the other end (not shown in figure).
A second block of mass m rests on top of the larger block.
The human lowers the blocks, causing them to accelerate downwards with magnitude $0.275g$.
Note: block m is placed perfectly so block $3m$ doesn't tip & allow m to slide left or right.
Friction is negligible. Assume g is known.



***2a) Determine tension (magnitude) in the cable.
Answer as a number with 3 sig figs times mg.

***2b) Determine normal force (magnitude) acting between the blocks.
Answer as a number with 3 sig figs times mg.

2a	
2b	

Let us call $\vec{n}_{down}$ the normal force exerted *downwards* by block m on block $3m$.
Let us call $\vec{n}_{up}$ the normal force exerted *upwards* by block $3m$ on block m.

2c) Which normal force has larger *magnitude* as the blocks *accelerate downwards*?

$n_{up} > n_{down}$	$n_{up} = n_{down}$	$n_{up} < n_{down}$	Impossible to determine without more info

2d) Which normal force would have larger magnitude *if the blocks were lowered with constant speed*?

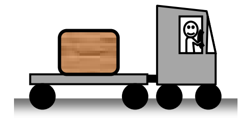
$n_{up} > n_{down}$	$n_{up} = n_{down}$	$n_{up} < n_{down}$	Impossible to determine without more info

**2e) Describe the reaction force associated with the weight of block $3m$. 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

A flat-bed truck accelerates from rest at a rate of $3.50\,\frac{\text{m}}{\text{s}^2}$ across a level surface.
A box on the bed remains at rest (relative to the truck) as it accelerates forwards.
Assume $\mu_s = \mu_k$ for these surfaces.
****3a) Determine the *minimum* coefficient of friction required to keep the block from sliding across the bed of the truck. Assume $g = 9.8\,\frac{\text{m}}{\text{s}^2}$.



3a	

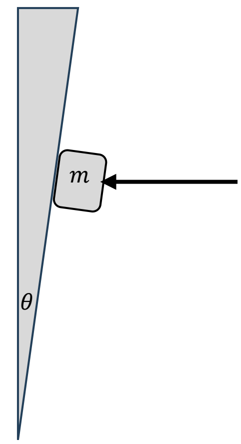
3b) Suppose the truck accelerated at a slightly ***slower*** rate (compared to the original problem described in part a). Which of the following statements would be true?

n & f remain unchanged	n increases & f remains unchanged	n decreases & f remains unchanged	Impossible to determine without more info
n remains unchanged & f increases	n increases & f increases	n decreases & f increases	
n remains unchanged & f decreases	n increases & f decreases	n decreases & f decreases	None of the others is true

3b) Suppose the truck accelerated at a slightly ***faster*** rate (compared to the original problem described in part a). Which of the following statements would be true?

n & f remain unchanged	n increases & f remains unchanged	n decreases & f remains unchanged	Impossible to determine without more info
n remains unchanged & f increases	n increases & f increases	n decreases & f increases	
n remains unchanged & f decreases	n increases & f decreases	n decreases & f decreases	None of the others is true

A block is pressed against a wall which is angled θ from the vertical.
Frictional coefficients between m & the angled wall are μ_s & μ_k.
A force may be applied horizontally to mass m. Assume g is known and θ is drawn to scale.



4a) Suppose we wish to determine the minimum force (applied horizontally) to hold m in place.
Which of the following friction conditions most likely applies?

$f = 0$	$f < \mu_s n$	$f = \mu_s n$	$f = \mu_k n$	Impossible to determine without more info

******4b) Determine the minimum force (applied horizontally) to hold m in place.

4b	

***4c) Suppose θ was decreased slightly but the horizontal applied force was held constant.
Which best describes what happens to each of the following forces or force components?
Note: the block is still held motionless.

Component of weight parallel to the angled surface	Increases	Decreases	Stays the same	Impossible to determine without more info

Normal force	Increases	Decreases	Stays the same	Impossible to determine without more info

Frictional force	Increases	Decreases	Stays the same	Impossible to determine without more info

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