

Please remove this sheet before starting your exam.

Things you must have memorized

The Momentum Principle Definition of Momentum	The Energy Principle Definition of Velocity	The Angular Momentum Principle Definition of Angular Momentum
Definitions of angular velocity, particle energy, kinetic energy, and work		

Other potentially useful relationships and quantities

$$\gamma \equiv \frac{1}{\sqrt{1 - \left(\frac{|\vec{v}|}{c}\right)^2}}$$

$$\frac{d\vec{p}}{dt} = \frac{d|\vec{p}|}{dt} \hat{p} + |\vec{p}| \frac{d\hat{p}}{dt}$$

$$\vec{F}_{grav} = -G \frac{m_1 m_2}{|\vec{r}|^2} \hat{r}$$

$$|\vec{F}_{grav}| \approx mg \text{ near Earth's surface}$$

$$\vec{F}_{elec} = \frac{1}{4\pi\epsilon_0} \frac{q_1 q_2}{|\vec{r}|^2} \hat{r}$$

$$|\vec{F}_{spring}| = k_s s$$

$$U_i \approx \frac{1}{2} k_{si} s^2 - E_M$$

$$\vec{r}_{cm} = \frac{m_1 \vec{r}_1 + m_2 \vec{r}_2 + \dots}{m_1 + m_2 + \dots}$$

$$K_{tot} = K_{trans} + K_{rel}$$

$$K_{rot} = \frac{L_{rot}^2}{2I}$$

$$\vec{L}_A = \vec{L}_{trans,A} + \vec{L}_{rot}$$

$$\omega = \sqrt{\frac{k_s}{m}}$$

$$Y = \frac{F/A}{\Delta L/L} \text{ (macro)}$$

$$\Omega = \frac{(q + N - 1)!}{q! (N - 1)!}$$

$$\text{prob}(E) \propto \Omega(E) e^{-\frac{E}{kT}}$$

$$E^2 - (pc)^2 = (mc^2)^2$$

$$\vec{F}_{\parallel} = \frac{d|\vec{p}|}{dt} \hat{p} \text{ and } \vec{F}_{\perp} = |\vec{p}| \frac{d\hat{p}}{dt} = |\vec{p}| \frac{|\vec{v}|}{R} \hat{n}$$

$$U_{grav} = -G \frac{m_1 m_2}{|\vec{r}|}$$

$$\Delta U_{grav} \approx mg \Delta y \text{ near Earth's surface}$$

$$U_{elec} = \frac{1}{4\pi\epsilon_0} \frac{q_1 q_2}{|\vec{r}|}$$

$$U_{spring} = \frac{1}{2} k_s s^2$$

$$\Delta E_{thermal} = mC \Delta T$$

$$I = m_1 r_{1\perp}^2 + m_2 r_{2\perp}^2 + \dots$$

$$K_{rel} = K_{rot} + K_{vib}$$

$$K_{rot} = \frac{1}{2} I \omega^2$$

$$\vec{L}_{rot} = I \vec{\omega}$$

$$v = d \sqrt{\frac{k_{si}}{m_a}}$$

$$Y = \frac{k_{si}}{d} \text{ (micro)}$$

$$S \equiv k \ln \Omega$$



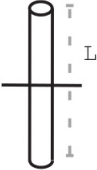
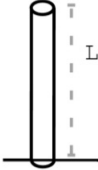
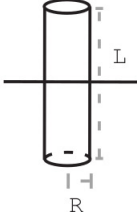
$$E_N = -\frac{13.6 \text{ eV}}{N^2} \text{ where } N = 1, 2, 3 \dots$$

$$E_N = N \hbar \omega_0 + E_0 \text{ where } N = 0, 1, 2 \dots \text{ and } \omega_0 = \sqrt{\frac{k_{si}}{m_a}} \text{ (Quantized oscillator energy levels)}$$

Moment of inertia for rotation about indicated axis

The cross product

$$\vec{A} \times \vec{B} = \langle A_y B_z - A_z B_y, A_z B_x - A_x B_z, A_x B_y - A_y B_x \rangle$$

				
$I = \frac{2}{5}MR^2$	$I = \frac{1}{2}MR^2$	$I = \frac{1}{12}ML^2$	$I = \frac{1}{3}ML^2$	$I = \frac{1}{12}ML^2 + \frac{1}{4}MR^2$

Constant	Symbol	Approximate Value
Speed of light	c	3×10^8 m/s
Gravitational constant	G	6.7×10^{-11} N · m ² /kg ²
Approx. grav field near Earth's surface	g	9.8 N/kg
Electron mass	m_e	9×10^{-31} kg
Proton mass	m_p	1.7×10^{-27} kg
Neutron mass	m_n	1.7×10^{-27} kg
Electric constant	$\frac{1}{4\pi\epsilon_0}$	9×10^9 N · m ² /C ²
Proton charge	e	1.6×10^{-19} C
Electron volt	1 eV	1.6×10^{-19} J
Avogadro's number	N_A	6.02×10^{23} atoms/mol
Plank's constant	h	6.6×10^{-34} joule · second
$\hbar = \frac{h}{2\pi}$	\hbar	1.05×10^{-34} joule · second
specific heat capacity of water	C	4.2 J/g/K
Boltzmann constant	k	1.38×10^{-23} J/K

milli	m	1×10^{-3}
micro	μ	1×10^{-6}
nano	n	1×10^{-9}
pico	p	1×10^{-12}

kilo	k	1×10^3
mega	M	1×10^6
giga	G	1×10^9
tera	T	1×10^{12}

PHYS 2211 M - Test 2 - Summer 2022

Please clearly print your name & GTID in the lines below

Name: _____ GTID: _____

Instructions

- This exam is closed internet/books/notes, except for the Formula Sheet which is included with the exam.
- You must work individually and receive no assistance from any person or resource.
- You are not allowed to post screenshots, files, or any other details of the test anywhere online, not even after the test is over.
- Work through all the problems first, then scan/upload your solutions after time is called.
 - Your uploaded files **must** be in either PNG, JPG, or PDF format.
 - Your uploaded files must be readable in order to be graded. Unreadable files will earn a zero.
 - You can upload a single file containing work for multiple problems as long as you upload the file for each problem individually.
 - Clearly label your work for each sub-part and box the final answers.
- To earn partial credit, your work must be legible and the organization must be clear.
 - Your solution should be worked out algebraically.
 - Numerical solutions should only be evaluated at the last step. Incorrect solutions that are not solved algebraically will receive an 80 percent deduction.
 - You must show all work, including correct vector notation.
 - **Correct answers without adequate explanation will be counted wrong.**
 - Incorrect work or explanations mixed in with correct work will be counted wrong. Cross out anything you do not want us to grade
 - Make explanations correct but brief. You do not need to write a lot of prose.
 - Include diagrams!
 - **Show what goes into a calculation, not just the final number, e.g.:** $\frac{a \cdot b}{c \cdot d} = \frac{(8 \times 10^{-3})(5 \times 10^6)}{(2 \times 10^{-5})(4 \times 10^4)} = 5 \times 10^4$
 - Give standard SI units with your numeric results. Your symbolic answers should not have units.

Unless specifically asked to derive a result, you may start from the formulas given on the formula sheet, including equations corresponding to the fundamental concepts. If a formula you need is not given, you must derive it.

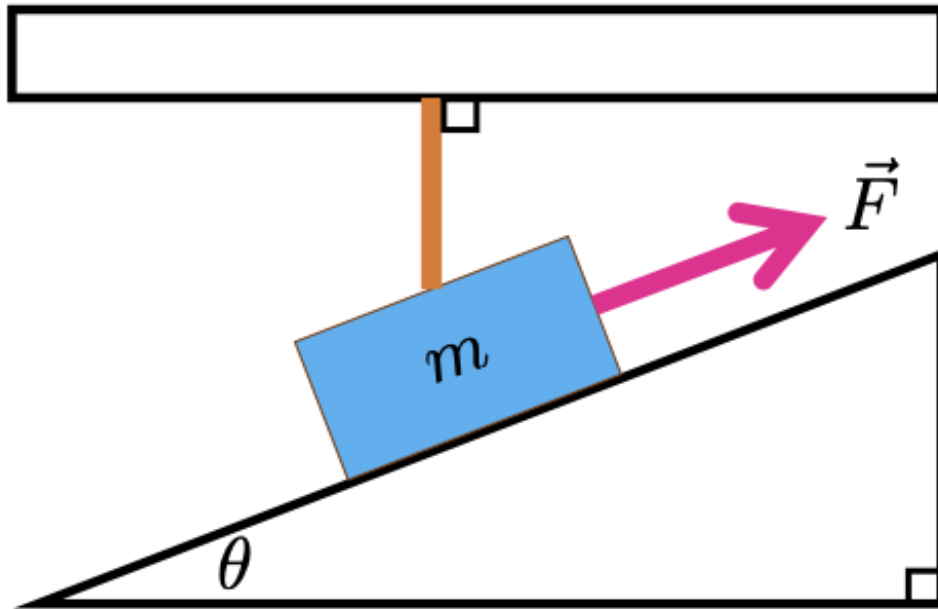
If you cannot do some portion of a problem, invent a symbol for the quantity you can not calculate (explain that you are doing this), and use it to do the rest of the problem.

**“In accordance with the Georgia Tech Honor Code,
I have not given or received unauthorized aid on this test.”**

Sign your name on the line above

Ramp - Q2 on Gradescope [30 pts]

A block of mass $m = 10$ kg sits on a **frictionless** ramp that has inclination angle $\theta = 20$ degrees. A rope connects the block to the ceiling. The rope hangs straight down and exerts a tension $T = 50$ N on the block. In order to keep the block sitting still, you need to apply a force F up along the ramp as shown in the diagram.

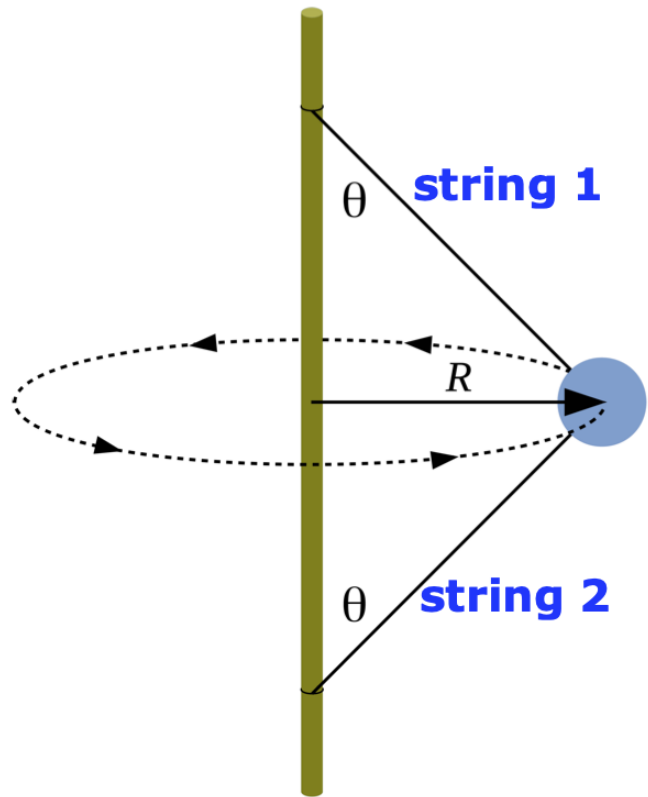


1. [10 pts] Draw a free-body-diagram showing all the forces acting on the block. To receive full credit, your diagram must have correctly labeled axes, forces, and angles.

2. [20 pts] Determine the magnitude of the force F that you need to apply to keep the block at rest.

Spin Toy – Q2 in Gradescope [30 pts]

Consider the toy represented in the image to the right. This toy is made by attaching a ball of mass m to a wooden stick by means of two identical strings, each of which makes an angle θ with the stick. When you rotate the stick between the palms of your hands, the ball travels in a circle of radius R at constant speed v . In the diagram gravity points down, and the circular path of the ball is flat and in a plane that is parallel with the ground.

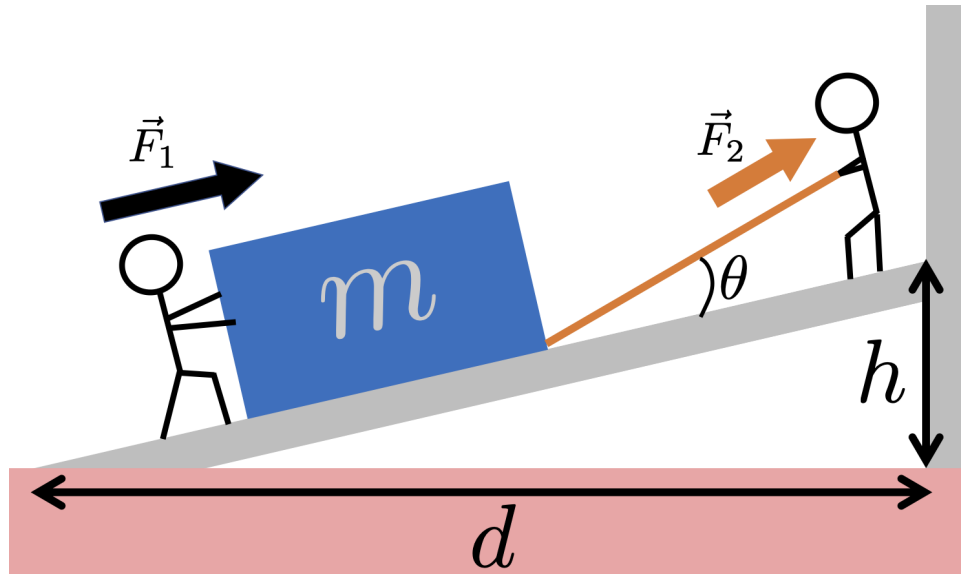


1. [10 pts] Draw a free-body diagram where the system is the ball at the location shown in the diagram. Your diagram should include all the relevant axes and all the forces acting on the ball in the correct directions and with correct angles, where applicable. Hint: think of what are the \hat{p} , \hat{n} , and \hat{y} axes in this problem.

2. [20 pts] Determine the magnitude of the tension T_2 due to string 2.

Pushing and Pulling [40 pts]

The movers are trying to get a heavy crate (mass m) up a ramp into the loading dock of a building. One of the movers is pushing on the crate with a force of constant magnitude F_1 parallel with the surface of the ramp. The other mover is pulling a rope attached to the crate, exerting a force of constant magnitude F_2 , oriented at an angle θ above the surface of the ramp.



1. [20 pts] The crate started on the ground a horizontal distance d away from the building, and when it got into the building's loading dock it was at a height h above the ground. What is the total amount of work the two movers did on the crate as it was moved from the ground into the loading dock?

2. [20 pts] There is no friction between the crate and the surface of the ramp. The movers applied their forces continuously (i.e., constant forces). Given this information, and the fact that the crate started at rest at the bottom of the ramp, determine how fast the crate moves when it reaches the top of the ramp.

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