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UNIVERSITY OF MICHIGAN

Physics 140 – Fall 2007

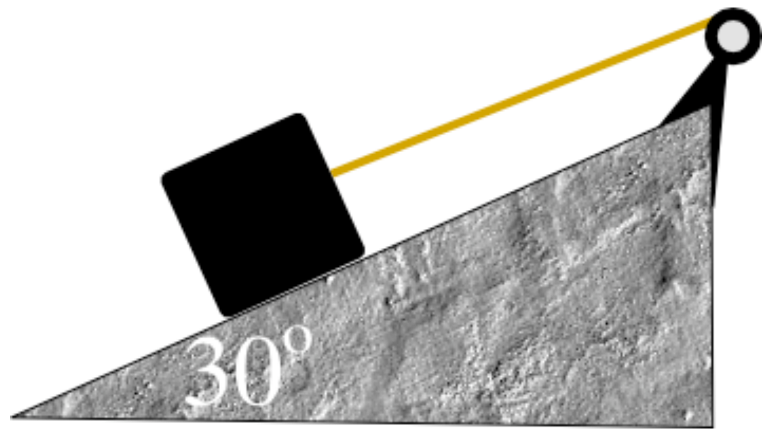
midterm #3 review

Bad logic -
What equation do I use?

Good logic -
What information do I know?
What information am I being asked to find?
What key ideas/conceptual tools do I apply?
What equations express these ideas?

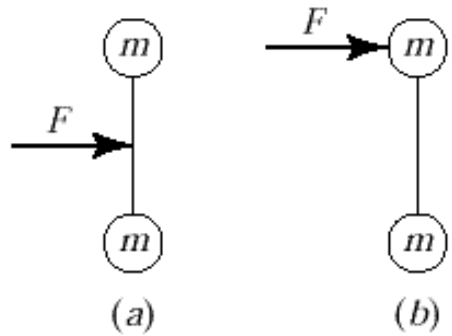
Comparison of linear and rotational motion

Quantity	**Linear Motion**	**Rotational Motion**
displacement	$\boldsymbol{x}$	θ
velocity	$\boldsymbol{v}$	ω
acceleration	$\boldsymbol{a}$	α
inertia	m	$I \sim (\text{constant})mr^2$
kinetic energy	$K_{\text{trans}} = 1/2\ mv^2$	$K_{\text{rot}} = 1/2\ I\omega^2$
momentum	$\boldsymbol{p} = m\boldsymbol{v}$	$\boldsymbol{L} = I\omega$
2^{nd} Law (dynamics)	$\Sigma\ \boldsymbol{F} = \text{d}\boldsymbol{p}/\text{d}t$	$\Sigma\ \tau = \text{d}L/\text{d}t$
work	$W = F_{\parallel}\ \Delta x$	$W = \tau\ \Delta\theta$
conservation law	$\Delta\boldsymbol{p} = 0$ if $\Sigma\boldsymbol{F}_{\text{ext}}=0$	$\Delta\boldsymbol{L} = 0$ if $\Sigma\tau_{\text{ext}}=0$
impulse	$\boldsymbol{F}\Delta t = \Delta\boldsymbol{p}$	$\tau\ \Delta t = \Delta\boldsymbol{L}$



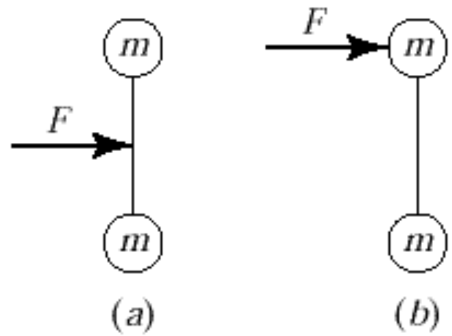
A block of mass *m* fastened by a light rope to a massive pulley slides along a frictionless ramp. The pulley has radius *r*, moment of inertia *I*, and the tension in the rope is *T*. In solving for the angular motion of the pulley, which of the following concepts & equations will you need to apply?

1. **definition of torque: $\tau = r\, T$**
2. **linear and angular accelerations: $a = r\,\alpha$**
3. **Newton's second law on the block: $F_{net} = ma$**
4. **circular motion: $a = v^2/r$**
5. **both 1 and 2**
6. **1, 2 and 3** ←
7. **all of 1-4**



Two dumbbells rest on a horizontal, frictionless surface (top view shown above). A force F is applied to each dumbbell for a short time interval Δt, either: (a) at the center or (b) at one end. After the impulses are applied, how do the center-of-mass velocities of the dumbbells compare?

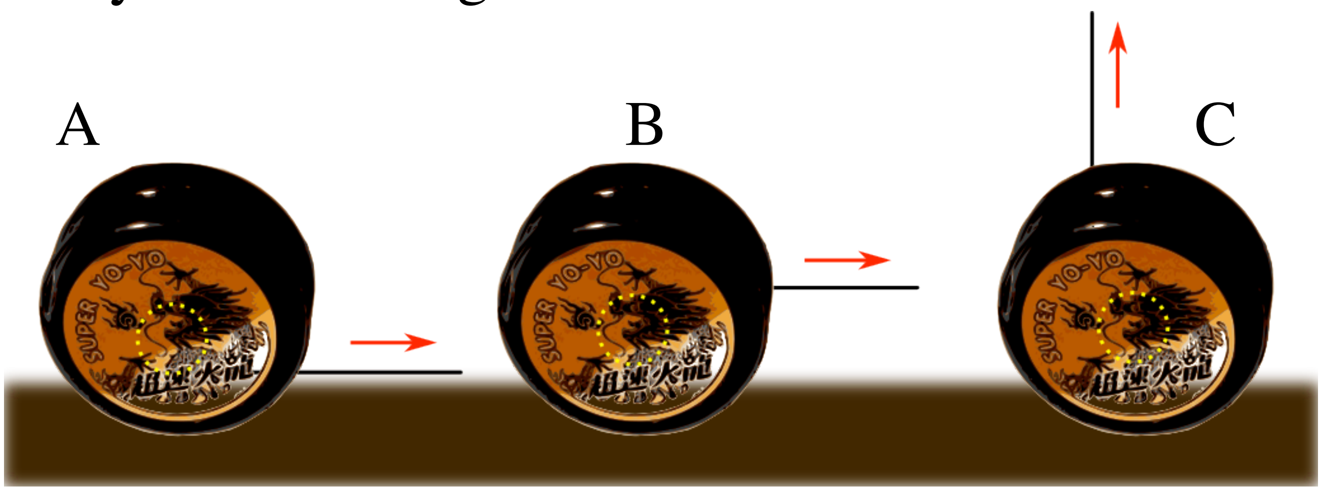
1. (a) is greater than (b)
2. (b) is greater than (a)
3. no difference
4. can't tell



Two dumbbells rest on a horizontal, frictionless surface (top view shown above). A force F is applied to each dumbbell for a short time interval Δt, either: (a) at the center or (b) at one end. After the impulses are applied, how do the total kinetic energies of the dumbbells compare?

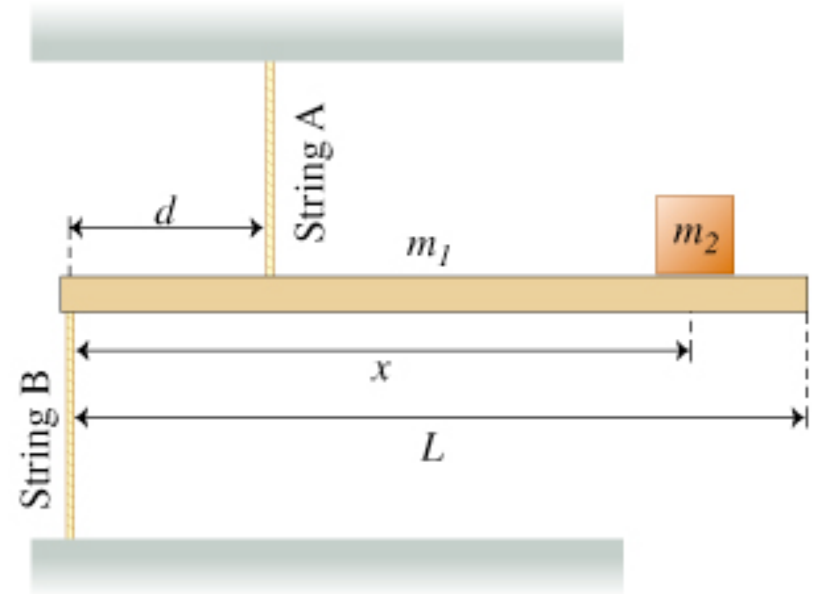
1. (a) is greater than (b)
2. (b) is greater than (a)
3. no difference
4. can't tell

A yo-yo of mass m is placed on a horizontal table, with static friction coefficient μ_s between the two. In the three cases shown below, the string of the yo-yo is pulled gently, with force $F < \mu_s mg$, in the direction shown. In which case(s) will the yo-yo initially roll to the right?



1) A
2) B
3) C
4) Both B and C
5) All of A, B and C

A rigid, uniform, horizontal bar of mass m_1 and length L is supported by two light, vertical strings. String A is attached at a distance $d < L/2$ from the left end while string B is attached to the left end. A small block of mass m_2 is supported against gravity by the bar at a distance x from the left end of the bar. If the system is in static equilibrium, which of the following statements is ***always true***?



1. The tension in string B is greater than zero.
2. The tension in string A is greater than that of B.
3. The tension in string B does not depend on *x*.
4. The torque about location *x* is greater than zero.
5. The tension in string B is smallest when *x* = *L*.

Our *sensation* of weight is derived from the *normal forces* that operate on our body to counteract the attractive force of gravity. **A feeling of *weightlessness* occurs whenever normal forces are removed**. This can happen

in deep `empty' space,

or in low Earth orbit (centripetal acceleration = g),

or while driving too fast over the crest of a hill!

In all of these cases, normal forces would not be acting (albeit momentarily, in the last case) on your body.

Conversely, `artificial gravity' can be created by establishing a normal force that acts on your feet. In space, one can use the centripetal acceleration required for uniform circular motion to establish such `gravity' in a rotating space station.

See Stanley Kubrick's *2001, A Space Odyssey*.

Two satellites (*A* and *B*) of the same mass are going around Earth in circular orbits. The radius of the orbit of satellite B is twice that of satellite *A*. What is the ratio of the total orbital energy of *B* to that of *A*?

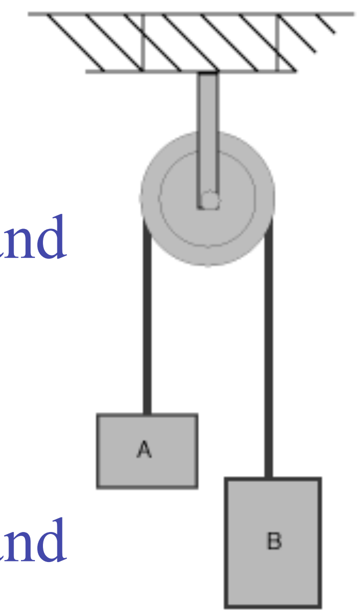
1. 1/8
2. 1/4
3. 1/2
4. $1/\sqrt{2}$
5. 1

Two satellites (*A* and *B*) are orbiting the earth in elliptical orbits of the same eccentricity. If the semi-major axis of B is twice that of satellite *A*, then

1. The mechanical energy of A has smaller magnitude than that of B.
2. The mechanical energy of B has smaller magnitude than that of A.
3. The angular momentum of A has larger magnitude than that of B.
4. The angular momentum of B has larger magnitude than that of A.
5. Both 1 and 3
6. Both 2 and 4

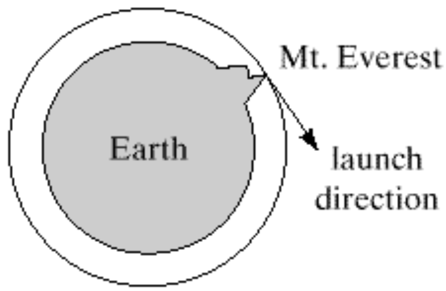
Chapter	**Concepts**	**Calculations**
9+10	3	6
11	2	4
12	2	3
total	7	13

An Atwood's machine consists of two masses A and B, with A heavier than B, connected across a massive, frictionless pulley by a light rope.



1. The center of mass position drops and center of mass speed increases.
2. The center of mass position stays the same and center of mass speed stays the same.
3. The center of mass position drops and center of mass speed stays the same.
4. The center of mass position stays the same and center of mass speed increases.

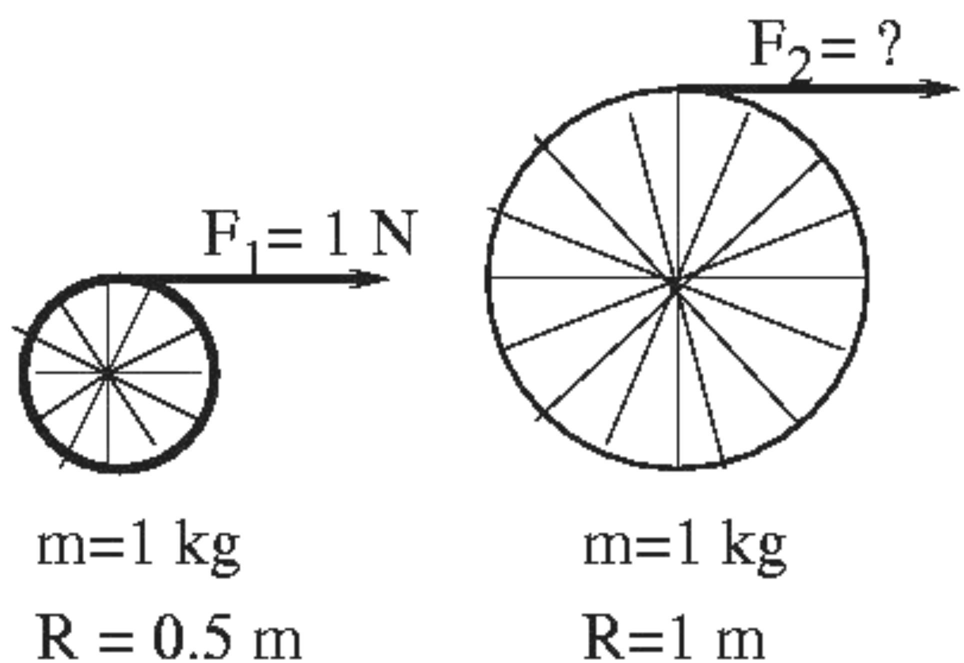
Suppose Earth had no atmosphere and a ball were fired from the top of Mt. Everest in a direction tangent to the ground. If the initial speed were high enough to cause the ball to travel in a circular trajectory around Earth, the ball's acceleration would

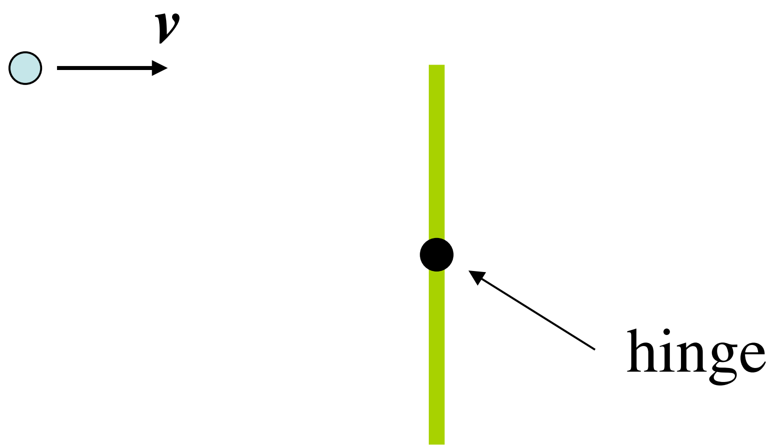


1. be much less than g (because the ball doesn't fall to the ground).
2. be approximately g.
3. depend on the ball's speed.

Forces are applied to two wheels mounted on stationary hubs, each having a mass of 1 kg. The force on wheel 1 has magnitude 1 N. Assuming that the hubs and the spokes are very light (massless), so that the rotational inertia is $I = mR^2$, how large must F_2 be in order to impart to wheel 2 the same angular acceleration as wheel 1?

1) 0.25 N
2) 0.5 N
3) 1 N
4) 2 N
5) 4 N

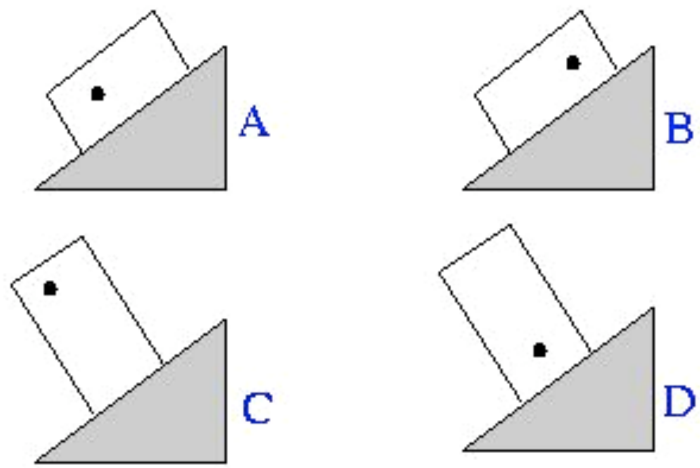




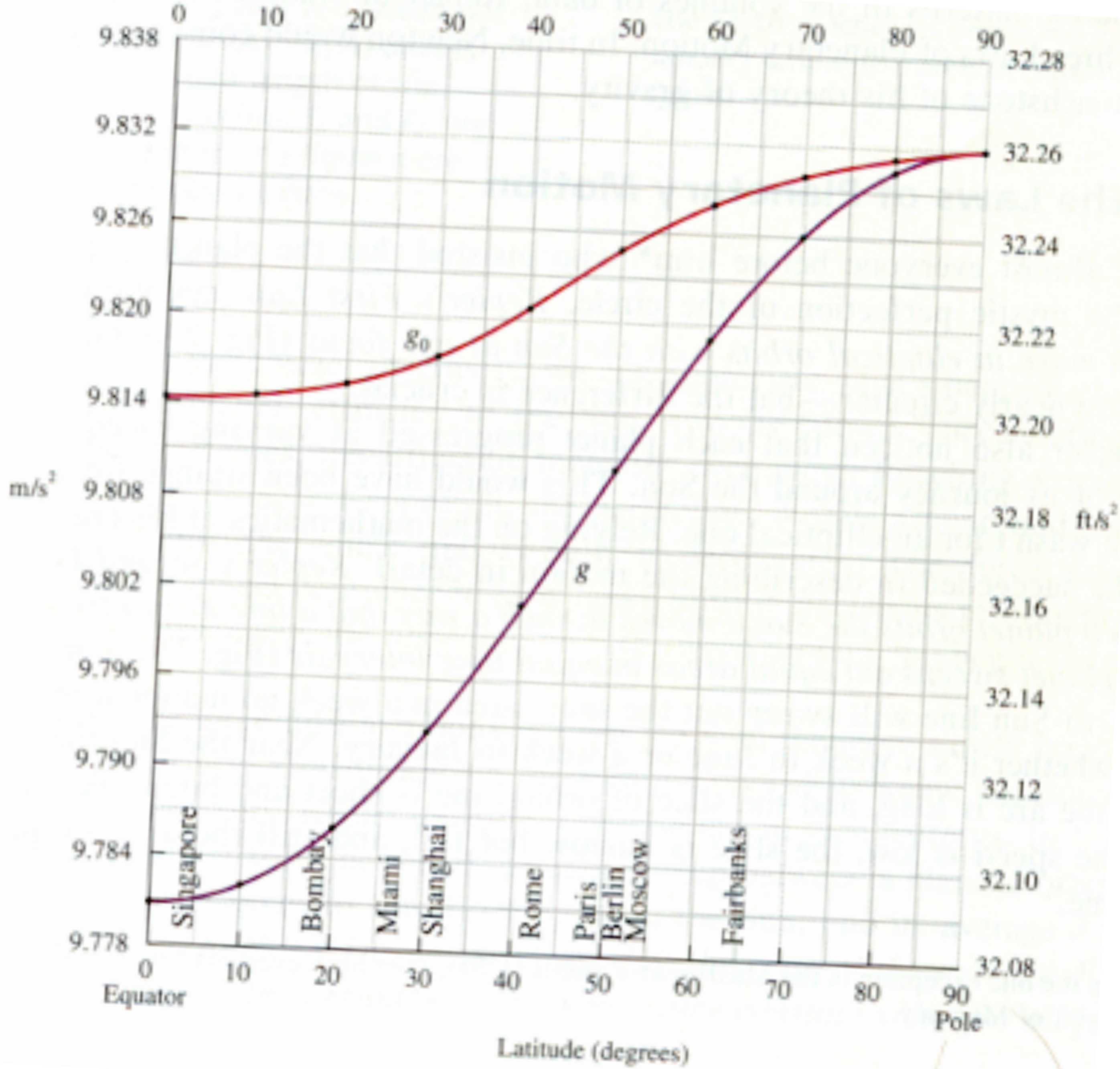
A ball of putty of mass m slides with velocity $\boldsymbol{v}$ across a frictionless ice toward a uniform rod of length L and mass $2m$ that is hinged at its center. After the putty and rod collide inelastically, which system quantities are conserved?

1. linear momentum
2. angular momentum
3. kinetic energy
4. both 1) and 2)
5. all of the above

A box, with its center-of-mass off-center as indicated by the dot, is placed on a rough inclined plane (so rough that the box does not slide). In which of the four orientations shown, if any, will the box tip over?



1. A
2. B
3. C
4. D



0
10
20
30
40
50
60
70
80
90
9.838
9.832
9.826
9.820
9.814
9.808
9.802
9.796
9.790
9.784
9.778
m/s²
32.28
32.26
32.24
32.22
32.20
32.18
32.16
32.14
32.12
32.10
32.08
ft/s²
g_0
g
Singapore
Bombay
Miami
Shanghai
Rome
Paris
Berlin
Moscow
Fairbanks
Equator
Pole
Latitude (degrees)

Bad logic -

1. What equation do I use?

Good logic -

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