Phys 3344: Office Hours: Wed 5:00-6:00 Phone #'s sheet Schedule: Exam #1: Thur/Friday 17-18 Sept Homework #3: **Atwood Machine:** No pulley With pulley **Divergence Theorem** Line Integrals





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Tuesday September 8th 6:30 PM

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	2020 FALL			L	PHYS 3344
#	DAY	LECTURE:	NOTES:	Chpt	TOPIC
1	TUE	08/25/20	First Class	1	Newtons Laws
2	THUR	08/27/20		2	Projectiles
3	TUE	09/01/20		3	Momentum & Angular Momentum
4	THUR	09/03/20		4	Energy
5	TUE	09/08/20		5	Oscillations
6	THUR	09/10/20	-		
7	TUE	09/15/20			
8	THUR	09/17/20	-		EXAM 1
9	TUE	09/22/20	-	6	Calculus of Variations
10	THUR	09/24/20	-	7	Lagrange's Equation
11	TUE	09/29/20			
12	THUR	10/01/20	-	8	Two Body Problems
13	TUE	10/06/20	23		
14	THUR	10/08/20		9	Non-Inertial Frames
	TUE	10/13/20	Fall Break	10	Rotational Motion
15	THUR	10/15/20	-		EXAM 2
16	TUE	10/20/20	5.	10	Rotational Motion
17	THUR	10/22/20	5		
18	TUE	10/27/20	5	11	Coupled Oscillations
19	THUR	10/29/20	5		
20	TUE	11/03/20	5	13	Hamiltonian Mechanics
21	THUR	11/05/20	Drop Date		
22	TUE	11/10/20	84		
23	THUR	11/12/20			EXAM 3
24	TUE	11/17/20	22	14	Collision Theory
25	THUR	11/19/20			
26	TUE	11/24/20		15	Special relativity
27	THUR	11/26/20	Thanksgiving		No Class
28	TUE	12/01/20			No Class
29	THUR	12/03/20	Last Class		Review
	WED	Dec 16	FINAL EXAM	Wedr	nesday Dec. 16,2020, 11:30am - 2:30
		-			
	Adjustn	nents may be	made depending on	studen	t interests/needs and unplanned events

Divergence theorem. In two dimensions, it is equivalent to Green's theorem

$$\int_{V} \partial F = \int_{\partial V} F$$

 $\cdot \mathbf{F}) \ dV = \oint_{C} (\mathbf{F} \cdot \mathbf{n}) \ dS.$

volume integral

$$\iiint_V (\nabla$$

000

NameIntegral equationsDifferential equationsGauss's law
$$surface$$

integral $\iint_{\partial\Omega} \mathbf{E} \cdot d\mathbf{S} = 4\pi \iiint_{\Omega} \rho \, dV$ $volume$
integral $\nabla \cdot \mathbf{E} = 4\pi \rho$ Gauss's law for magnetism $\iint_{\partial\Omega} \mathbf{B} \cdot d\mathbf{S} = 0$ $\nabla \cdot \mathbf{B} = 0$ Maxwell–Faraday equation
(Faraday's law of induction) $\oint_{\partial\Sigma} \mathbf{E} \cdot d\boldsymbol{\ell} = -\frac{1}{c} \frac{d}{dt} \iint_{\Sigma} \mathbf{B} \cdot d\mathbf{S}$ $\nabla \times \mathbf{E} = -\frac{1}{c} \frac{\partial \mathbf{B}}{\partial t}$ Ampère's circuital law (with
Maxwell's addition) $\oint_{\partial\Sigma} \mathbf{B} \cdot d\boldsymbol{\ell} = \frac{1}{c} \left(4\pi \iint_{\Sigma} \mathbf{J} \cdot d\mathbf{S} + \frac{d}{dt} \iint_{\Sigma} \mathbf{E} \cdot d\mathbf{S} \right)$ $\nabla \times \mathbf{B} = \frac{1}{c} \left(4\pi \mathbf{J} + \frac{\partial \mathbf{E}}{\partial t} \right)$

Conservative Forces: if $F=-\nabla U$

$$F = -\nabla U \qquad \int_{a}^{b} F = \int_{a}^{b} -\nabla U = -U_{b} + U_{a} = \Delta U_{ab}$$
 Independent of path

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F = m a F_T - m₁ g = m₁ a₁ F_T - m₂ g = m₂ a₂ a₁ = - a₂ Unknowns: F_T, a₁, a₂

Figure 4.15 An Atwood machine consisting of two masses, m_1 and m_2 , suspended by a massless inextensible string that passes over a massless, frictionless pulley. Because the string's length is fixed, the position of the whole system is specified by the distance x of m_1 below any convenient fixed level. The forces on the two masses are their weights m_1g and m_2g , and the tension forces F_T (which are equal since the pulley and string are massless).

EXAMPLE 3.4 A Sliding and Spinning Dumbbell

A dumbbell consisting of two equal masses m mounted on the ends of a rigid massless rod of length 2b is at rest on a frictionless horizontal table, lying on the x axis and centered on the origin, as shown in Figure 3.10. At time t = 0, the left mass is given a sharp tap, in the shape of a horizontal force \mathbf{F} in the y direction, lasting for a short time Δt . Describe the subsequent motion.



tap in the y direction.

EXAMPLE 3.4 A Sliding and Spinning Dumbbell

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There are actually two parts to this problem: We must find the initial motion immediately after the impulse, and then the subsequent, force-free motion. The initial motion is not hard to guess, but let us derive it using the tools of this chapter. The only external force is the force **F** acting in the y direction for the brief time Δt . Since $\dot{\mathbf{P}} = \mathbf{F}^{\text{ext}}$, the total momentum just after the impulse is $\mathbf{P} = \mathbf{F} \Delta t$. Since $\mathbf{P} = M\dot{\mathbf{R}}$ (with M = 2m), we conclude that the CM starts moving directly up the y axis with velocity

$$\mathbf{v}_{\rm cm} = \dot{\mathbf{R}} = \mathbf{F} \, \Delta t / 2m$$
.

While the force **F** is acting, there is a torque $\Gamma^{\text{ext}} = Fb$ about the CM, and so, according to (3.28), the initial angular momentum (just after the impulse has



Figure 3.10 The left mass of the dumbbell is given a sharp tap in the *y* direction.

ceased) is $L = Fb \Delta t$. Since $L = I\omega$, with $I = 2mb^2$, we conclude that the dumbbell is spinning clockwise, with initial angular velocity

$$\omega = F \,\Delta t / 2mb.$$

The clockwise rotation of the dumbbell means that the left mass is moving up relative to the CM with speed ωb , and its total initial velocity is

$$v_{\text{left}} = v_{\text{cm}} + \omega b = F \Delta t / m$$

By the same token the right mass is moving down relative to the CM, and its total initial velocity is

$$v_{\rm right} = v_{\rm cm} - \omega b = 0.$$

That is, the right mass is initially stationary, while the left one carries all the momentum $F \Delta t$ of the system.

The subsequent motion is very straightforward. Once the impulse has ceased, there are no external forces or torques. Thus the CM continues to move straight up the y axis with constant speed, and the dumbbell continues to rotate with constant angular momentum about the CM and hence constant angular velocity.

Cosmic rays (atomic nuclei stripped bare of their electrons) would continuously bombard E arth's surface if most of them were not deflected by E arth's magnetic field. G iven that E arth is, to an excellent approximation, a magnetic dipole, the intensity of cosmic rays bombarding its surface is greatest at the



- 1. poles.
- 2. mid-latitudes.
- 3. equator.

Consider the four field patterns shown. A ssuming there are no charges in the regions shown, which of the patterns represent(s) a possible electrostatic field:









- 1. (*a*)
- 2. (b)
- 3. (b) and (d)
- 4. (*a*) and (*c*)

- 5. (b) and (c)
- 6. some other
 - combination
- 7. None of the above.

A person swings on a swing. When the person sits still, the swing oscillates back and forth at its natural frequency. If, instead, the person stands on the swing, the new natural frequency of the swing is

- 1. greater.
- 2. the same.
- 3. smaller.

A person swings on a swing. When the person sits still, the swing oscillates back and forth at its natural frequency. If, instead, two people sit on the swing, the new natural frequency of the swing is

- 1. greater.
- 2. the same.
- 3. smaller.

A mass suspended from a spring is oscillating up and down as indicated. Consider two possibilities: (*i*) at some point during the oscillation the mass has zero velocity but is accelerating (positively or negatively); (*ii*) at some point during the oscillation the mass has zero velocity and zero acceleration.



- 1. Both occur sometime during the oscillation.
- 2. Neither occurs during the oscillation.
- 3. Only (i) occurs.
- 4. Only (ii) occurs.