Phys 3344:

Office Hours: Wed 5:00-6:00  Phone #'s sheet

Schedule: Exam #1: Thur/Friday 17-18 Sept

Homework #3:

Atwood Machine:

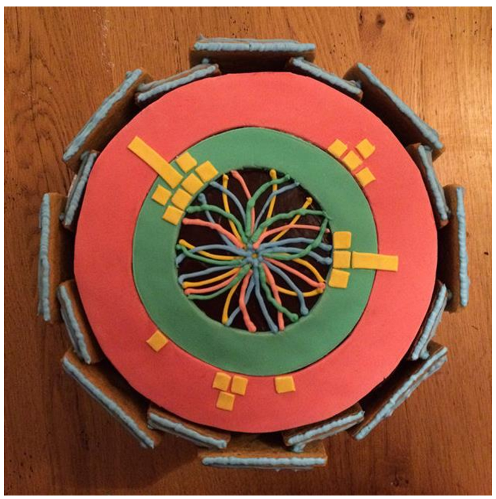
- No pulley
- With pulley

Divergence Theorem

Line Integrals

https://smu.zoom.us/j/9066747242

# Join the **Society of Physics Students** for **Physics Cakes** by Dr. Katharine Leney



Tuesday September 8th

6:30 PM

https://smu.zoom.us/j/9066747242

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| | 2020 FALL 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 | | | |
| ***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 | | 10 | Rotational Motion |
| ***17*** | THUR | 10/22/20 | | | |
| ***18*** | TUE | 10/27/20 | | 11 | Coupled Oscillations |
| ***19*** | THUR | 10/29/20 | | | |
| ***20*** | TUE | 11/03/20 | | 13 | Hamiltonian Mechanics |
| ***21*** | THUR | 11/05/20 | Drop Date | | |
| ***22*** | TUE | 11/10/20 | | | |
| ***23*** | THUR | 11/12/20 | | | **EXAM 3** |
| ***24*** | TUE | 11/17/20 | | 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** | **Wednesday Dec. 16,2020, 11:30am - 2:30** | |
| | | | | | |
| | ***Adjustments may be made depending on student interests/needs and unplanned events*** | | | | |

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

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

volume integral

$$\iiint_V (\nabla \cdot \mathbf{F})\, dV = \oiint_S (\mathbf{F} \cdot \mathbf{n})\, dS.$$

surface integral

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

Conservative Forces: if F=- ∇U

$$F = -\nabla U$$

$$\int_a^b F = \int_a^b -\nabla U = -U_b + U_a = \Delta U_{ab}$$

Independent of path

# Contents









* Sections marked with an asterisk could be omitted on a first reading.

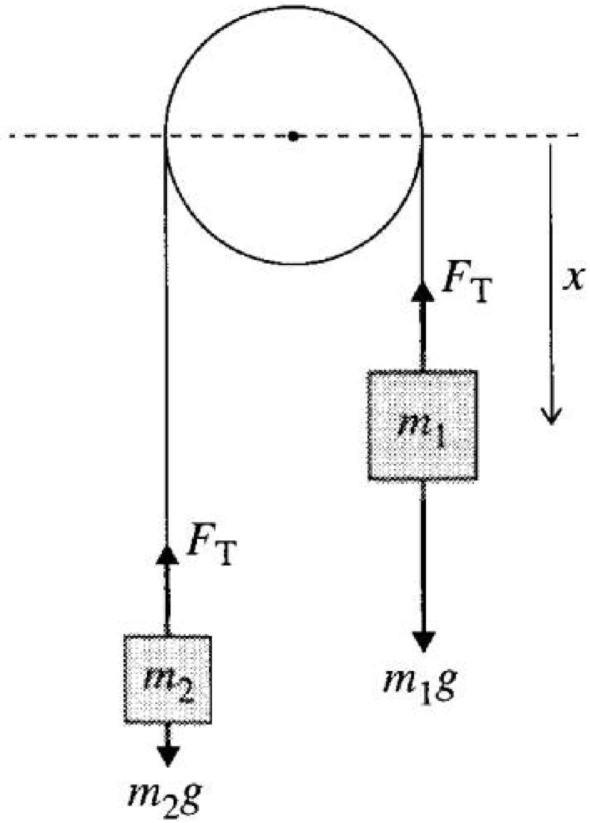



Figure 4.15 An Atwood machine consisting of two masses, $m_1$ and $m_2$, suspended by a massless inextensible string that passes over a massless, frictionless pulley. Because the string's length is fixed, the position of the whole system is specified by the distance $x$ of $m_1$ below any convenient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

$$F = m\,a$$

$$F_T - m_1\,g = m_1\,a_1$$

$$F_T - m_2\,g = m_2\,a_2$$

$$a_1 = -\,a_2$$

Unknowns: $F_T$, $a_1$, $a_2$

## 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 $\Delta t$. Describe the subsequent motion.

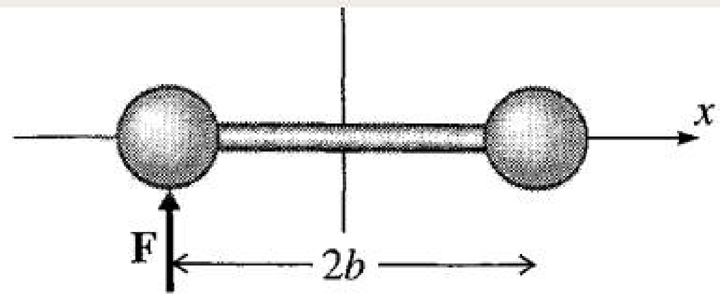



Figure 3.10 The left mass of the dumbbell is given a sharp tap in the $y$ direction.

### 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 $\Delta t$. Describe the subsequent motion.

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 $\mathbf{F}$ acting in the $y$ direction for the brief time $\Delta t$. 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

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

While the force $\mathbf{F}$ 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

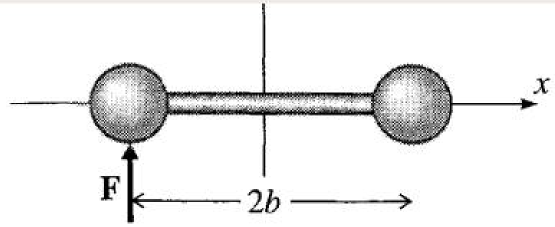



Figure 3.10 The left mass of the dumbbell is given a sharp tap in the $y$ direction.

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 $\omega b$, and its total initial velocity is

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

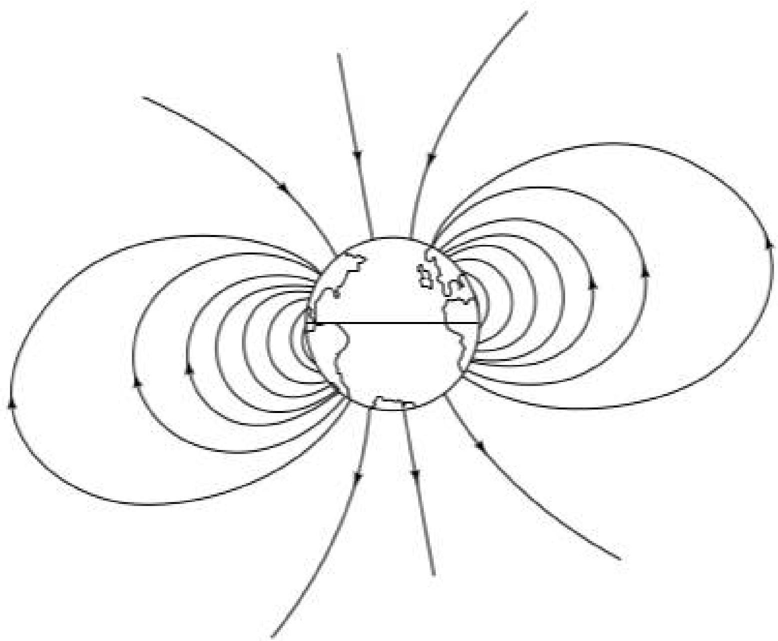
By the same token the right mass is moving down relative to the CM, and its total initial velocity is

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

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

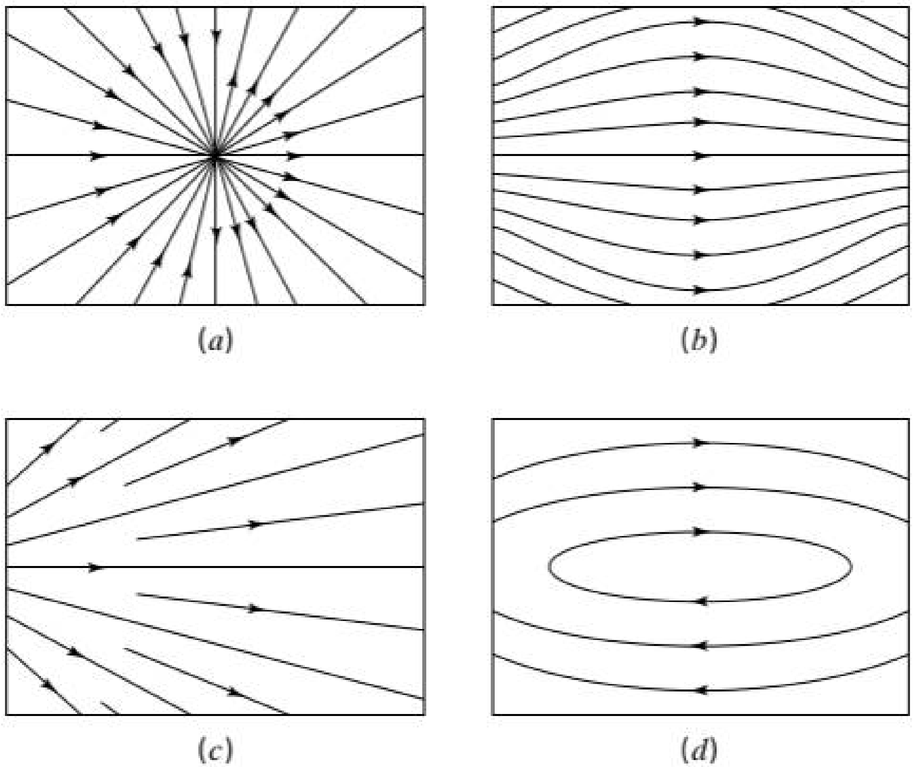
The subsequent motion is very straightforward. Once the impulse has ceased, there are no external forces or torques. Thus the CM continues to move straight up the $y$ axis with constant speed, and the dumbbell continues to rotate with constant angular momentum about the CM and hence constant angular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

Cosmic rays (atomic nuclei stripped bare of their electrons) would continuously bombard Earth's surface if most of them were not deflected by Earth's magnetic field. Given that Earth 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 s-
suming 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.

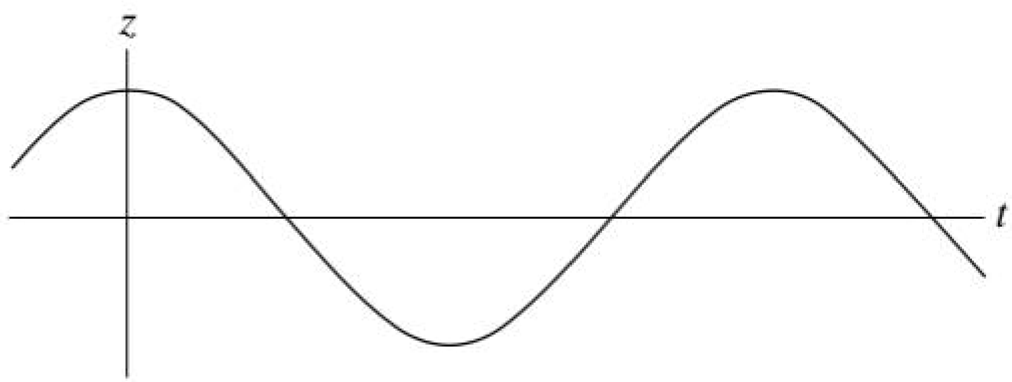
A person swings on a swing. When the person sits still, the swing oscillates back and forth at its natural frequency. If, instead, the person stands on the swing, the new natural frequency of the swing is

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.