Panel 1

ES204 Mechanical Systems

Introduction to Impact
Lecture 06

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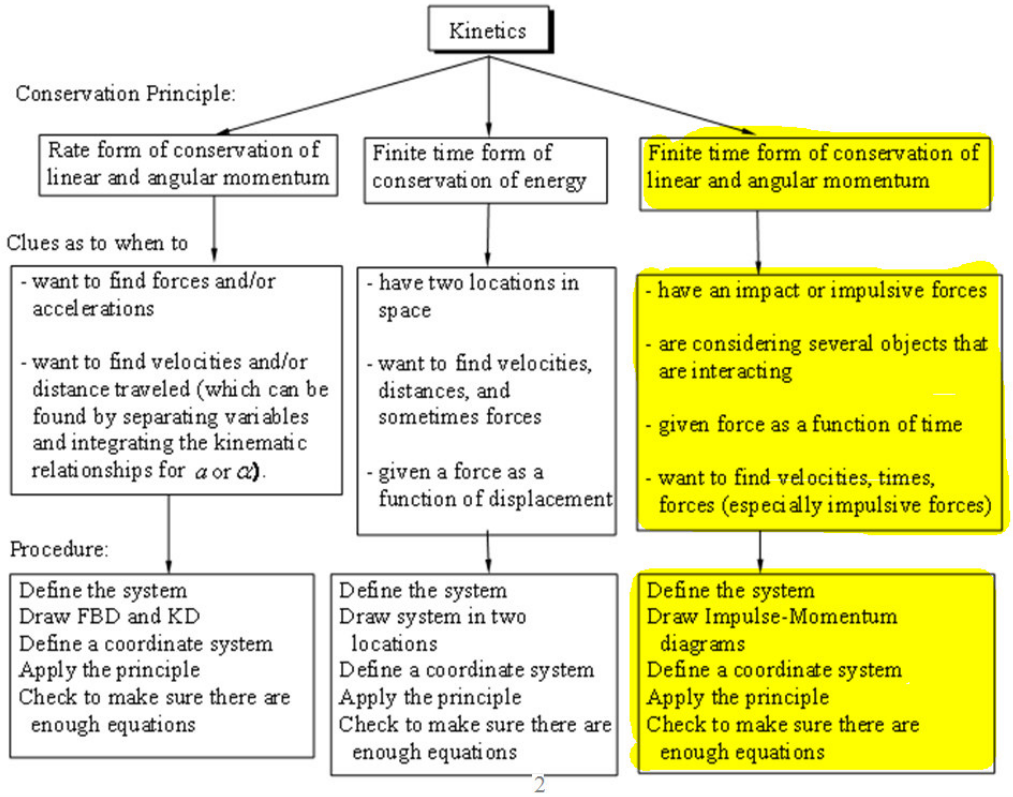
Dr. Fisher

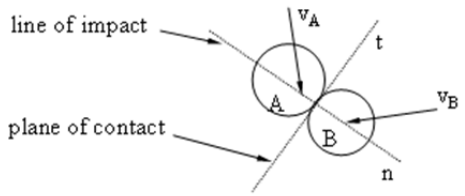
Panel 2



2

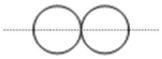
Panel 3

Draw the impact to label directions

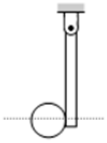


Terminology

Central Impact: Both mass centers are located on the line of impact (always true for particles).



Eccentric Impact: Both mass centers are not located on the line of impact.



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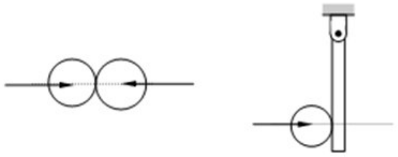
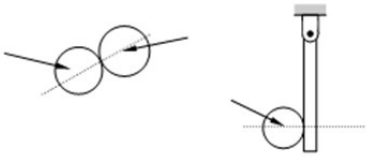
Panel 4

Terminology (cont.)

Direct Impact: Both velocities, v_A and v_B, lie along the line of impact.



Oblique Impact: Both velocities, v_A and v_B, do not lie along the impact.



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Panel 5

Velocity Type of Impact

Center of Mass Type of Impact	Direct Impact (Both velocities on line of impact)	Oblique Impact (Velocities NOT along impact)
Central Impact (Both masses on the line of impact)	Direct Central	Oblique Central
Eccentric Impact (Mass centers NOT along line of impact	Direct Eccentric	Oblique Eccentric

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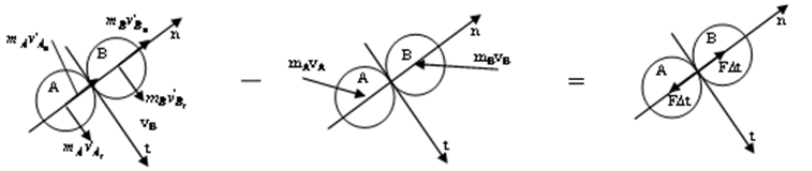
Panel 6

Procedure

1. Draw Impulse-momentum diagrams. You can do each object individually or both of them together. Label the n and t directions.



Momentum after time interval — Momentum before time interval = Impulses during time interval

2. If you have two objects hitting each other you will have a total of two independent systems. Using conservation of linear momentum (finite time) you can get a total of 4 independent equations. Sometimes it is useful to look at both objects together and other times individually. Do whatever is clearer for you.

3. If the objects bounce off of each other you will need to use the "**coefficient of restitution**" (experimentally determined for a given combination of materials, assumed to be constant).

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Panel 7

Coefficient of restitution

$$e = -\left(\frac{v'_{PB_n} - v'_{PA_n}}{v_{PB_n} - v_{PA_n}}\right) \quad \text{or} \quad v'_{PB_n} - v'_{PA_n} = -e\left(v_{PB_n} - v_{PA_n}\right) = e\left(v_{PA_n} - v_{PB_n}\right)$$

where

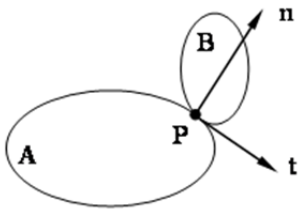
e = the coefficient of restitution $(0 \le e \le 1)$

v'_{PA_n} = the velocity of the point of contact on object A in the normal direction after the impact

v'_{PB_n} = the velocity of the point of contact on object B in the normal direction after the impact

v_{PA_n} = the velocity of the point of contact on object A in the normal direction before the impact

v_{PB_n} = the velocity of the point of contact on object B in the normal direction before the impact



For many problems this will reduce to: $v'_{B_n} - v'_{A_n} = e\left(v_{A_n} - v_{B_n}\right)$

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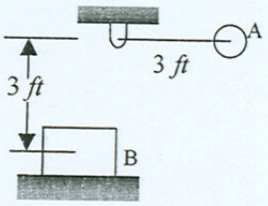
Panel 8

Ball A has a weight of 6 lb and block B has a weight of 18 lb. If A is released from rest and the coefficient of restitution between A and B is 0.5, determine the velocity of A and B just after the impact.



What kinetic solving strategies do we need?

Phase 1:

Phase 2:

Kinetic methods:

1. Rate form of Conservation of Momentum

2. Engergy

3. Finite form of Conservation of Momentum

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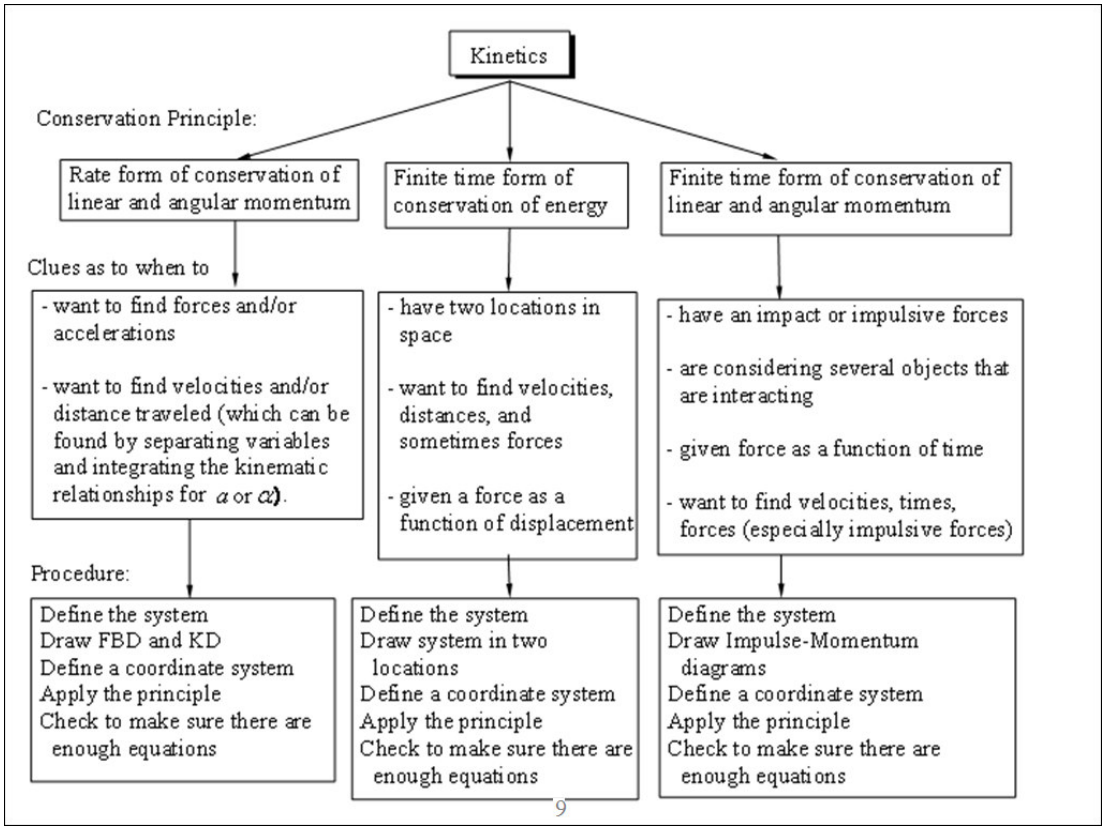
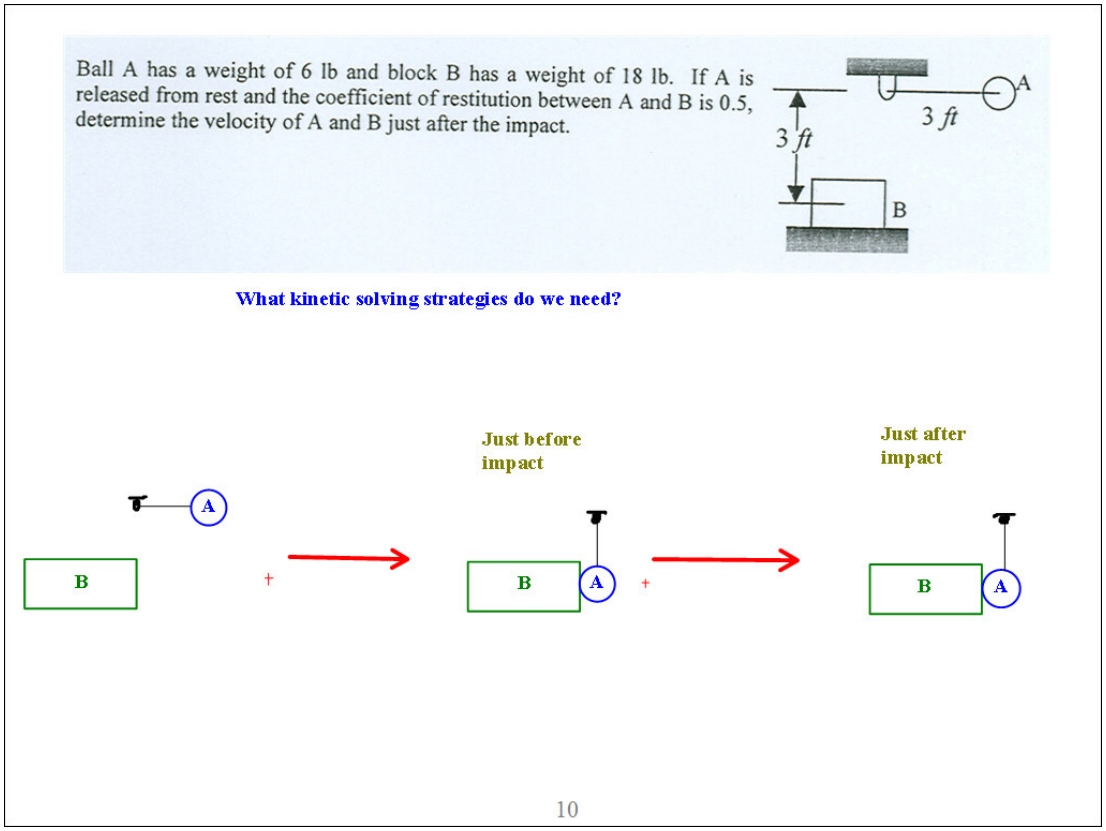
Panel 9

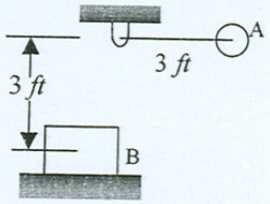


Panel 10



Panel 11

Ball A has a weight of 6 lb and block B has a weight of 18 lb. If A is released from rest and the coefficient of restitution between A and B is 0.5, determine the velocity of A and B just after the impact.



Just before impact

Energy

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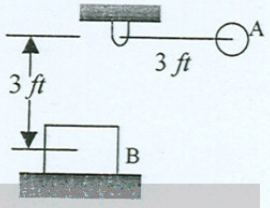
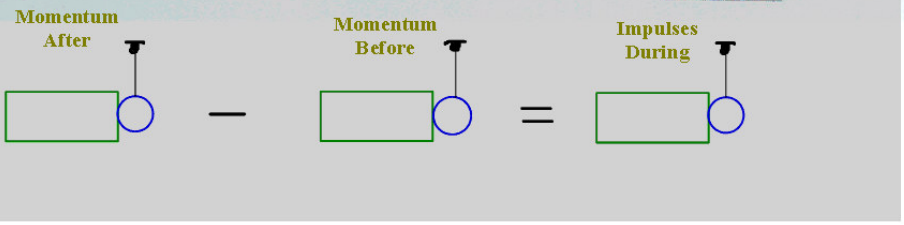
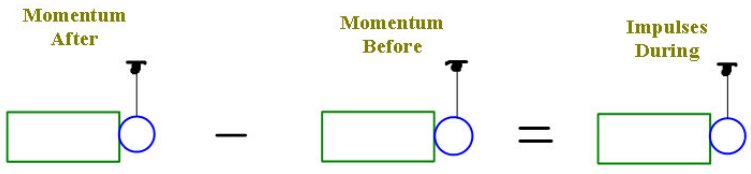
Panel 12

Ball A has a weight of 6 lb and block B has a weight of 18 lb. If A is released from rest and the coefficient of restitution between A and B is 0.5, determine the velocity of A and B just after the impact.



Draw on the momentums at the different times





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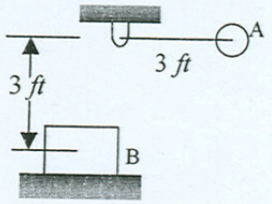
Panel 13

Ball A has a weight of 6 lb and block B has a weight of 18 lb. If A is released from rest and the coefficient of restitution between A and B is 0.5, determine the velocity of A and B just after the impact.



Momentum After

Momentum Before

Impulses During

Conservation of LM for the system with A & B together

Momentum After - Momentum Before = Impulses During

+

+

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Panel 14

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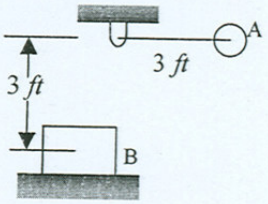
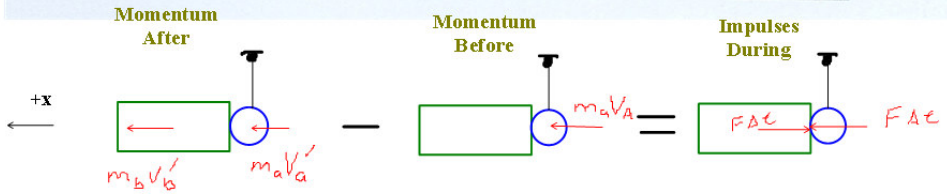
Panel 15

Ball A has a weight of 6 lb and block B has a weight of 18 lb. If A is released from rest and the coefficient of restitution between A and B is 0.5, determine the velocity of A and B just after the impact.





Coefficient of Restitution equation

general form of the equation $\longrightarrow$ $e = -\dfrac{V'_{PB_N} - V'_{PA_N}}{V_{PB_N} - V_{PA_N}}$

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Panel 16

From the conservation of linear momentum

From the coefficient of restitution equation

Solution

$v_A' = -1.74$ ft/s

$v_B' = 5.21$ ft/s

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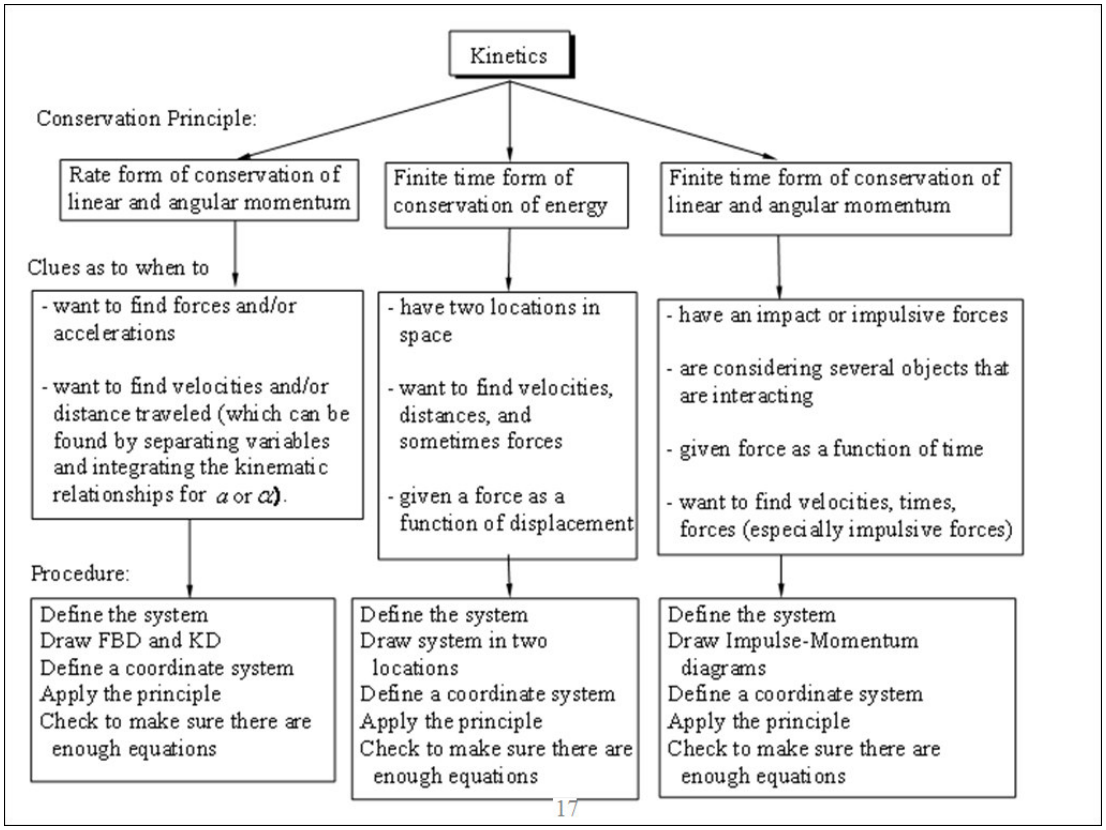
Panel 17


Kinetics
Conservation Principle:
Rate form of conservation of linear and angular momentum
Finite time form of conservation of energy
Finite time form of conservation of linear and angular momentum
Clues as to when to
- want to find forces and/or accelerations
- want to find velocities and/or distance traveled (which can be found by separating variables and integrating the kinematic relationships for a or α).
- have two locations in space
- want to find velocities, distances, and sometimes forces
- given a force as a function of displacement
- have an impact or impulsive forces
- are considering several objects that are interacting
- given force as a function of time
- want to find velocities, times, forces (especially impulsive forces)
Procedure:
Define the system
Draw FBD and KD
Define a coordinate system
Apply the principle
Check to make sure there are enough equations
Define the system
Draw system in two locations
Define a coordinate system
Apply the principle
Check to make sure there are enough equations
Define the system
Draw Impulse-Momentum diagrams
Define a coordinate system
Apply the principle
Check to make sure there are enough equations
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