I. How do I Form Cooperative Groups?

What size groups should I form?

For discussion and laboratory sections, form groups of **three**. Previous research indicates that groups of three work better than pairs or groups of four. With pairs, there is often not enough physics knowledge to solve the problem. In groups of four, one member tends to be left out of the process.

When your class size is not divisible by three, however, you will end up with a few pairs or a group of four. For discussion sections form groups of four. For the laboratory, break the group of four into two pairs.

How do I assign students to groups?

Previous research indicates that mixed-ability groups (based on past performance on problem-solving tests) work better than homogeneous-ability groups. In addition, groups of two men and one woman do not work well, particularly at the beginning of the course. (The men tend to ignore the woman, even if she is the highest ability student in the group.) Until you get to know your students, try groups of three men, three women, or two women and one man. Use the following procedure:

1. Write each student's total test scores, gender, and major on either index cards or a computer spreadsheet, as illustrated below.

2. Compute a cumulative total score for each student.

Name	Test 1	Test 2	Total	Perf.	Gender	Major	Group
Anderson, Max	62	71	133		Male	Arch	
Black, Jennifer	93	85	178		Female	Ecol	
Brown, John	78	79	157		Male	Phar	
Edwards, Mark	54	58	112		Male	Dent	
Fairweather, Joan	73	65	138		Female	Vet	
Freedman, Joshua	55	49	104		Male	Arch	
Good, Mary	100	95	195		Female	Phy Th	
Green, Bill	79	83	162		Male	Arch	
Johnson, Fred	69	70	139		Male	Arch	
Jones, Rachel	59	63	122		Female	Wildlife	
Peterson, Scott	69	61	130		Male	Arch	
Smith, Patricia	70	77	147		Female	Arch	

South, David	48	50	98		Male	Phar	
West, Tom	52	55	107		Male	Vet	
White, Sandra	86	92	178		Female	Math	

3. Sort your class by total cumulative score (highest to lowest). Divide the class into thirds (high performance, medium performance and low performance students). Identify the performance level of each student.

Name	Test 1	Test 2	Total	Perf.	Gender	Major	Group
Good, Mary	100	95	195	High	Female	Phy Th	1
Black, Jennifer	93	85	178	High	Female	Ecol	2
White, Sandra	86	92	178	High	Female	Math	3
Green, Bill	79	83	162	High	Male	Arch	4
Brown, John	78	79	157	High	Male	Phar	5
Smith, Patricia	70	77	147	Medium	Female	Arch	2
Johnson, Fred	69	70	139	Medium	Male	Arch	3
Fairweather, Joan	73	65	138	Medium	Female	Vet	1
Anderson, Max	62	71	133	Medium	Male	Arch	4
Peterson, Scott	69	61	130	Medium	Male	Arch	5
Jones, Rachel	59	63	122	Low	Female	Wildlife	3
Edwards, Mark	54	58	112	Low	Male	Dent	2
West, Tom	52	55	107	Low	Male	Vet	5
Freedman, Joshua	55	49	104	Low	Male	Arch	1
South, David	48	50	98	Low	Male	Phar	4

4. Assign three students to a group -- one high performance, one medium performance, and one low performance. If the class size is not divisible by three, assign one or two groups with four members (or pairs for computer labs).

   Assign by gender -- two women and one man, three women, or three men. Never have a group with more men than women. Never end up with *all* single-gender groups (e.g., 4 groups of men and 1 group of women).

   If possible, mix the groups by major (e.g., try not to have three architecture majors or electrical engineering majors in the same group).

   Note: If you do this procedure on a spreadsheet, you can assign each student a group number, sort by group number, and get a printout of your groups.

Name	Test 1	Test 2	Total	Perf.	Gender	Major	Group
Good, Mary	100	95	195	High	Female	Phy Th	1
Fairweather, Joan	73	65	138	Medium	Female	Vet	1
Freedman, Joshua	55	49	104	Low	Male	Arch	1
Black, Jennifer	93	85	178	High	Female	Ecol	2
Smith, Patricia	70	77	147	Medium	Female	Arch	2
Edwards, Mark	54	58	112	Low	Male	Dent	2
White, Sandra	86	92	178	High	Female	Math	3
Jones, Rachel	59	63	122	Low	Female	Wildlife	3
Johnson, Fred	69	70	139	Medium	Male	Arch	3
Green, Bill	79	83	162	High	Male	Arch	4
Anderson, Max	62	71	133	Medium	Male	Arch	4
South, David	48	50	98	Low	Male	Phar	4
Brown, John	78	79	157	High	Male	Phar	5
Peterson, Scott	69	61	130	Medium	Male	Arch	5
West, Tom	52	55	107	Low	Male	Vet	5

How often should I change the groups?

Formal cooperative groups need to stay together long enough to be successful. On the other hand, they should be changed often enough so students realize they can make *any* group successful -- that their success is not due to being in a "magic" group.

In the first semester, change groups after each test (3 to 4 times). In the second semester, you can change only 2 - 3 times.

In the beginning of the course, it is important to give students a rationale for assigning them to groups and changing groups often. We tell our students that:

(a) "We want you to get to know everyone in the class, so we will change groups often. By the end of the term, you will have worked with almost everyone in this class (section)."

(b) "No matter what career you enter, you will have to work cooperatively with many different kinds of people (not just your friends). So you should begin to learn how to work comfortably and successfully in groups."

NOTES:

II. How Can I Structure Group Work to Maintain Well-functioning Groups?

With structure and guidance, most students learn to function relatively well in groups. Occasionally, a group may exhibit one of the following dysfunctional behaviors (see Johnson and Johnson, 1989):

- Less able members sometimes "leave it to John" to solve the group problem, creating a **free-rider** effect.
- At the same time, more able group members expend decreasing amounts of effort to avoid the **sucker** effect.
- High ability group members may be deferred to and take over leadership roles in ways that benefit them at the expense of the other group members (the **rich-get-richer** effect).
- Groups with no natural leaders may avoid conflict by "voting" rather than discussing an issue (**conflict avoidance** effect).
- Group members argue vehemently for their point of view and are unable to listen to each other or come to a group consensus (**destructive conflict** effect).

Below are suggestions to help you maintain good group functioning.

1. Seating Arrangement: In discussion section, make sure the seats are arranged so students are facing each other, "knee-to-knee." This makes it much harder for a student to remain uninvolved with a group. If you observe students sitting in a row, or one student sitting "outside" a pair, go over to the group and make them stand up and rearrange their chairs.

   In labs, make sure students are standing or sitting so they are all facing each other. In computer labs, make sure all students can see the screen. If you observe a group with one member doing all the work or one member left out, go over to the group and make them rearrange their seating/standing.

2. One Group Product in Discussion Section: To promote interdependence (and reduce dominance by one student), specify that only **one** problem solution can be turned in by each group and all members must sign the solution.

   Do **NOT** let students use their textbooks while solving the problem. (The only book students should be allowed to use is *The Competent Problem Solver*.) Students should be co-constructing a solution, using each other as resources. The mathematical relationships, fundamental principles, and specific concepts needed to solve the problem should be either listed on the same sheet as the problem statement or on the blackboard. (Note: This list should increase as the semester progresses -- do

not give students only the relationships they need to solve the problem. See Homework #7 for examples.)

Do **NOT** let each student in a group first solve the problem individually, then discuss their solutions. **THIS IS NOT COOPERATIVE-GROUP PROBLEM SOLVING.** If students persist in this behavior after a reminder, you may need to take the pencils away from the Manager and Skeptic (see below). Only the Recorder / Checker should be writing.

3. Roles: Assign each student a specific role (Manager, Recorder / Checker, and Skeptic / Summarizer). These roles were selected to correspond to the planning and monitoring strategies individuals must perform *independently* when solving problems -- the manager who designs plans of action; the skeptic, who questions premises and plans; the recorder, who organizes and writes what has been done so far. In addition, each person has a responsibility to make sure the group functions effectively. The Manager must ensure that everyone in the group participates and contributes. The Checker / Recorder must ensure that all group members can explicitly explain how the problem was solved. The Skeptic / Summarizer keeps track of decisions and reasons for different actions, and summarizes them for the group.

   The first time students work together, each member is *assigned* one of these roles. Each subsequent time the same group works together, their roles **MUST ROTATE.** This is particularly important for the computer labs. One way to accomplish this is to list the group members with roles (M, R, S) on the board. You can use a spreadsheet to keep track of the roles you have assigned to each group member, as illustrated below.

Name	Group	DS 10/15	Lab 10/20	DS 10/22	Lab 10/27	DS 10/29	Lab 11/3
Good, Mary	1	M	S	R	M	S	R
Fairweather, Joan	1	R	M	S	R	M	S
Freedman, Joshua	1	S	R	M	S	R	M
Black, Jennifer	2	M	S	R	M	S	R
Smith, Patricia	2	R	M	S	R	M	S
Edwards, Mark	2	S	R	M	S	R	M
White, Sandra	3	M	S	R	M	S	R
Jones, Rachel	3	R	M	S	R	M	S
Johnson, Fred	3	S	R	M	S	R	M
Green, Bill	4	M	S	R	M	S	R
Anderson, Max	4	R	M	S	R	M	S
South, David	4	S	R	M	S	R	M
Brown, John	5	M	S	R	M	S	R
Peterson, Scott	5	R	M	S	R	M	S
West, Tom	5	S	R	M	S	R	M

Assigning and rotating roles helps to avoid both dominance by one student (the person with the pencil or keyboard has the real "power" in the group) and the free-rider effect. The roles also help groups that either avoid conflict or tend towards destructive conflict.

In well-functioning groups, all members share the roles of manager, checker, summarizer, and skeptic. The purpose of the roles is to give **you** a structure within which you can intervene to help groups that are not functioning well (see page 17).

4. In both discussion sections and lab, randomly call on individual students in a group to present their group's results. This person is *not* usually the Recorder / Checker for the group. In the beginning of the course, you can call on the individuals who seem most enthusiastic or involved. After students are familiar with group work, you can either call on the Skeptic / Summarizers or Managers, or call on individuals who seemed to be the least involved. This technique helps avoid both dominance by one student and the free-rider effect.

5. Group Processing: Set aside time at the end of a class session to have students discuss how well they worked together and what they could do to work together better next time (see pages 21-22).

At the beginning of the first semester, you should do group processing *every* class session. After two to three weeks (i.e., after students have worked in two different groups), you can reduce group processing to about once every two to three weeks, as it seems necessary (usually the first time new groups are working together).

6. Grading: Occasionally a group problem in discussion section is graded. Usually, the group test problem is given the day before the individual test. In the past we have found that with well designed problems (see Section IV-6) students tend to get their highest scores on the group tests. Although the group test questions are only about 15% of a student's grade in the course, this grading practice encourages students to work well together.

   To avoid the free-rider effect, your team may want to set the rule that a group member absent the week before the group test question (i.e., s/he did not get to practice with her/his group) cannot take the group test question. Towards the end of the first semester, you could let the rest of the group members decide if the absent group member can take the group test problem.

   To encourage students to work together in lab, your team could decide that each member of the group receives bonus points if all group members earn 80% or better on their individual lab problem reports.

NOTES:

III. How Do I Know When a Group is Not Functioning Well? Monitoring Groups

When students work in cooperative groups, they make hidden thinking processes overt, so these processes are subject to observation and commentary. You will be able to observe how students are constructing their understanding of physics concepts and the strategies they use to solve problems.

While groups are working, a significant fraction of your time should be spent **monitoring** (observing and listening to group members) in order to see

- what they do and do not understand, and
- what problems they have working together cooperatively.

With this knowledge, your interventions can be more efficient. **DO NOT get trapped into going from group to group explaining the task/physics or answering questions.** If you begin intervening too soon, it is not fair to the last groups. By the time you recognize that all groups may have the same difficulty, the last groups will have wasted considerable time.

Use the following steps to monitor groups:

1. Establish a circulation pattern around the room. Stop and observe each group to see how easily they are solving the problem and how well they are working together. Don't spend a long time observing any one group. Keep well back from students' line of sight so they don't focus on you.

2. Make mental notes about student difficulties with the task and with group functioning so you know which group to return to first.

3. If several groups are having the **same** difficulty, you may want to stop the whole class and clarify the task or make additional comments that will help the students get back on track (e.g., I noticed that you are all … Remember to …) Another strategy is to stop the class and have one group (or several groups) **show** the class how they did something. In discussion section, this may be how the group decided to draw their diagrams or what steps they are using to solve the problem. You can then spend a few minutes discussing how that drawing or plan could be done most effectively. In lab, a group could show how they decided to make certain measurements or carry out an analysis.

IV. How Can I Intervene When a Group is Not Functioning Well?

From your observations (circulation pattern), decide which group (if any) is obviously struggling and needs attention most urgently. Return to that group, watch for a moment and then join the group at eye level.

1. One way to intervene is to point out the problem and ask the appropriate group member what can be done about it. This establishes your role as one of **coach** rather than answer-giver. Another way to intervene is to ask a group: (a) What are you doing? (b) Why are you doing it? and (c) How will that help you? Try to give just enough help to get the group on track, then leave.

2. Another way to coach is to first diagnose the type of problem (e.g., managerial, came to decision too quickly without considering all the options, can't agree on what procedure to use, etc.) Then ask: "Who is the manager (or skeptic/summarizer, or recorder/checker)? What should you be doing to help resolve this problem?" If the student doesn't have any suggestions, then you could model several possibilities.

   Example #1: You observe a group in discussion section that is not talking to each other, but solving the group problem individually. First explain to the group that they should all be solving the problem together. Then ask: "Who is the Recorder/Checker? You should be the only person writing the solution." If necessary, make the students rearrange their chairs so they can all see what the Recorder/Checker is writing. If the students persist in solving the problem individually, return to the group, explain again that they should be solving the problem together, and take the pencils from the Manager and Skeptic (to be returned at the end of class).

   Example #2: You observe a group in discussion section that is having difficulty solving the group problem because they jumped into manipulating equations too quickly without qualitatively analyzing the problem (i.e., they did not draw diagrams and/or specify symbols for the unknown variables). Ask: "Who is the Manager? What useful problem-solving steps have been left out of your solution?" If necessary, have the Manager open *The Competent Problem Solver* and follow the Describe the Physics flow chart.

   Example #3: You see that a group is struggling to come to a decision. Ask the group: "Who is the Manager? I noticed that this group is having difficulty deciding . . . .? Manager, what could you be doing to help the group reach consensus about . . .? If the manager has no idea, give some suggestions, such as: “Stop and

summarize your different ideas. What are the advantages and disadvantages of each of these?"

Example #4: You see a group paper that has the wrong diagram or equation, or observe an inappropriate measurement plan in lab. Stop briefly, point to the diagram / equation / plan, and say: "Who is the Skeptic? What questions should you be asking about this diagram / equation / measurement plan?" Then leave.

3. If you observe a group in which one student does not seem to be involved in the discussion and decisions, ask that student to explain what the group is doing and why. This emphasizes the fact that **all** group members need to be able to explain each step in solving a problem.

4. If a group asks you a question, try to turn the question back to the group to solve. Again, try to give just enough help to get the group started, then leave.

Group Roles

In your discussion and laboratory sections for this course, you will be working in **cooperative** groups to solve written and experimental problems. To help you learn the material and work together effectively, each group member will be assigned a specific role. Your responsibilities for each role are defined on the chart below.

ACTIONS	WHAT IT SOUNDS LIKE
MANAGER	
DIRECT THE SEQUENCE OF STEPS.	*"LET'S COME BACK TO THIS LATER IF WE HAVE TIME."*
KEEP YOUR GROUP "ON-TRACK."	*"WE NEED TO MOVE ON TO THE NEXT STEP."*
MAKE SURE EVERYONE IN YOUR GROUP PARTICIPATES.	*"CHRIS, WHAT DO YOU THINK ABOUT THIS IDEA?"*
WATCH THE TIME SPENT ON EACH STEP.	
RECORDER/CHECKER	
ACT AS A SCRIBE FOR YOUR GROUP.	*"DO WE ALL UNDERSTAND THIS DIAGRAM?"*
CHECK FOR UNDERSTANDING OF ALL MEMBERS.	*"EXPLAIN WHY YOU THINK THAT."*
MAKE SURE ALL MEMBERS OF YOUR GROUP AGREE ON PLANS AND ACTIONS.	*"ARE WE IN AGREEMENT ON THIS?"*
MAKE SURE NAMES ARE ON GROUP PRODUCTS.	

SKEPTIC/SUMMARIZER HELP YOUR GROUP AVOID COMING TO AGREEMENT TOO QUICKLY. MAKE SURE ALL POSSIBILITIES ARE EXPLORED. SUGGEST ALTERNATIVE IDEAS. SUMMARIZE (RESTATE) YOUR GROUP'S DISCUSSION AND CONCLUSIONS.	*"WHAT OTHER POSSIBILITIES ARE THERE?"* *"LET'S TRY TO LOOK AT THIS ANOTHER WAY."* *"I'M NOT SURE WE'RE ON THE RIGHT TRACK."* *"WHY?"* *SO HERE'S WHAT WE'VE DECIDED SO FAR. . ."*

GROUP FUNCTIONING EVALUATION

In your group take a few minutes to discuss and answer these questions about this particular cooperative group learning experience. Focus your discussion on the **process** -- what you experienced, felt and thought while solving the discussion or lab problem.

1. What are **three** ways you did well in functioning as a cooperative group?

2. What problems did you have interacting as a cooperative group?

3. What is a **specific action** that would help you function and interact *even better* next time?

GROUP EVALUATION

Use the following grid to rate yourself on your participation and learning in this exercise. Also, agree on a group rating. 0 = Poor, 1 = Fair, 2 = Good, 3 = Excellent.

	Name	**Name**	**Name**	**Name**	**Group**
Preparation for Problem					
Participation in Solving the Problem					
Quality of Participation					
Use of the Problem Solving Roles					
Use of an Organized Approach to Solve the Problem					

1. What are **three** things you did well in solving this problem?

2. What **difficulties** did you encounter working as a group and how did you solve them?

3. What is a **specific action** that would help you function and interact *even better* next time?