

*GE Aircraft Engines – Jet Engine Design Challenge*

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**Overview**

The GE Challenge consists of two parts:

**Part A: Baseline Engine Assessment** - Individual solutions due **Thursday 2/26**

**Part B: Aircraft Engine Design Challenge** - Oral team presentations due **Friday 3/6**  
- Written team report due **Friday 3/13**

**Part A – Thermodynamic Cycle Analysis and Baseline Engine Assessment**

The first step is to carry out a thermodynamic cycle analysis and to assess whether the baseline engine meets the requirements (see GE problem statement and hand-out). Each team member is required to hand in the solution to Part A. You are allowed to discuss the concepts and the approach within the team but each team member is expected to carry out this analysis individually (homework rules apply for this part).

The governing equations, a short outline of the approach, an h-s diagram of the cycle, and the detailed solution to Part A must be summarized and handed in. The document should be short and succinct; it should focus on the concepts used and the interpretation of the results obtained (a discussion of the implications and the meaning of the results is expected). The baseline cycle solution in Part A is due on **Thursday February 26 by 10am**.

The solution and governing equations will be provided after the due date, and it is the responsibility of the individuals and the team to correct possible mistakes and to amend the cycle analysis for Part B.

**Part B – The Aircraft Engine Design Challenge**

*Teaming, Strategic Planning, and Design Space Exploration*

Team building and strategic planning are critical to winning the competition. Once the goals and objectives are set, the teams are advised to delegate tasks and responsibilities carefully. The idea is to identify individual responsibilities contributing towards the team effort. At the first team meeting the group's project success goals, the assigned tasks and responsibilities of each of the team members should be discussed and written down (first part of the team report). While it is expected that the strategic thinking and the reasoning through the engine design study is to be done by the entire team, some tasks can be assigned to individual members. For example, one team member might take

the lead on establishing a Matlab script to assess the effects of various cycle parameters, another team member might be in charge of compiling charts for the presentation and the report, etc.

The team is expected to respond to Part B in the GE assignment and work together towards developing a working cycle model which could be an Excel spreadsheet or a Matlab or Maple code that enables the thermodynamic cycle and engine performance to be calculated. Before exploring the design space, the team is advised to first reassess the baseline engine to verify the proper working of the script. It is suggested to make the cycle model parametric such that parameters can be easily varied in order to respond to the objectives of Part B. The goal is to be able to explain and to interpret your results (i.e. why does thermal efficiency have an optimum as a function of cycle pressure ratio) and to reason through your results using first principles arguments (i.e. the second law of thermodynamics dictates that ...). It is strongly recommended to plot the thermodynamic cycle and the parametric changes in an h-s or T-s diagram to investigate the performance trends.

An example of a parametric study is shown below. For fixed adiabatic component efficiencies, the plot illustrates the parametric assessment of the effect of turbine inlet temperature on thermodynamic efficiency as a function of cycle pressure ratio. The governing equation and the details can be found in section 11.6.5 of the 16. Unified Thermodynamics & Propulsion notes.

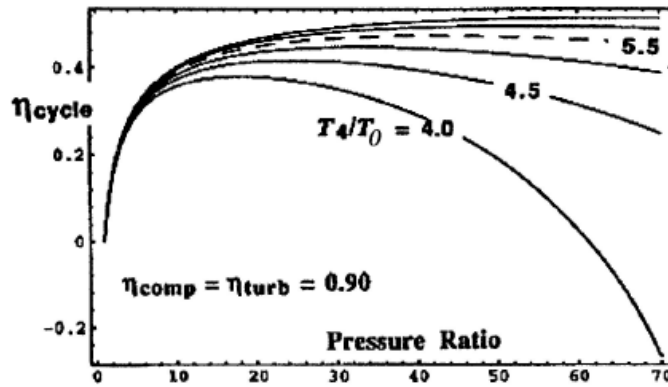


Figure 1: Effect of cycle pressure ratio and turbine inlet temperature on thermal efficiency for given component performance (from Cumpsty, N. "Jet Propulsion").

### Oral Team Presentation

Each team will be required to present the findings in an **oral presentation** on **Friday March 6** to a GE Aviation review committee. All teams and team members must be present during the presentations.

Each team member is required to participate in the presentation. The overall presentation should flow and the oral presentation must include: assumptions, the conceptual approach, the proposed engine design, and a discussion of the conclusions

and implications. The dress code for the presentations is business casual. Splitting the class into three rooms, twenty minutes will be allotted for the presentation and five minutes for questions and a short discussion with the review board. To avoid running over time, the teams are advised to rehearse the presentations for consistency and presentation length. Speakers will be interrupted if going over time.

### *Written Report*

Each team is asked to document their findings from Part B in a written report. The report must at least include the following: team member responsibilities and team success goal, problem statement and objectives, analytical approach, discussion of results (trends, implications, etc.), and conclusions. The team is asked to also attach clearly commented codes or scripts for Excel, Matlab, Maple, or any other program that was used as the cycle model. All of your findings should be presented clearly and succinctly in this report. The report may not exceed 10 pages, typed, with the exception of any scripts the team may attach in the appendices. The **written report** will be due **by 9 am on Friday March 13**.

### **Grading**

Part A of the GE Challenge will be graded on an individual basis and will count as one lab assignment. Part B will count as a second lab assignment and each team member will receive the team grade. Grading will be based on the approach, the technical correctness of the work, the team's ability to answer questions during presentations, professionalism, and insight. GE Aviation will award the winning team a prize.

# So, You're Going to be a Member of a Team ...

*By understanding the various types of teams and the stages teams go through, you can make the most of your team experience.*

Patricia L. Philips,  
Philips Consulting, Inc.

**Y**ou've been asked to be a member of a team by your manager. Perhaps what you remember most about being on a team is a Little League coach yelling from the sidelines, "Play your position! Play your position!"

The information in this article will help you "play your position" on your new team. It will describe the types of teams you may be asked to join, explain the key elements of a team, outline the stages of team development, describe effective team behaviors for each stage of development, and provide you with an action plan for your own team member development.

## What is a team?

A team can be defined as "two or more people who interact with each other, are interdependent, and define themselves and are defined by others as a team" (1).

The key words in this definition are *interact* and *interdependent*. A team is composed of individuals who are working together to accomplish a task or goal that alone they could not accomplish. If there is no interaction and interdependence, it isn't a team, just a group of individuals. Many companies fail to understand the importance of interaction and interdependence, and so will call any group of individuals that report to the same manager a team.

There are many types of teams that you may be asked to join during the course of your engineering career:

- Management team — a decision-making team, such as the CEO and senior executives, a corporate planning group, or a steering committee.

- Permanent work group team — people who work together on a regular basis and have a specific "organizational name," such as the process engineering design team, production group, waste minimization task force, or research department.

- Cross-functional team — a group of "experts" from various areas working together to complete a project. Areas that often institute cross-functional teams are research and development, production, marketing, and management.

- Temporary or special project team — people brought together to perform or accomplish a specific task or solve a particular problem; it may or may not be cross-functional in nature. Temporary or special project teams could be organized to debottleneck a process, improve yield, or incorporate new technology into a plant.

- Strategic alliance — a team of suppliers of services or products and their customers (for example, a purchasing alliance). To improve quality service to customers, strategic alliances are taking on the characteristics of teams and, as such, require similar group skills by those involved.

- Network — an informal group of people that may not have face-to-face contact, but are dependent upon each other for information, for expert advice, and for "alerts" about changes or problems. Examples of networks are secretaries, corporate and field staff, software users, and contractors. While networks have not been traditionally thought of as teams, it has been discovered that they, too, share team characteristics and the need for group skills (2).

Organizations today are making use of some or all of these teams and are reaping

many benefits from them, such as improved quality, increased productivity, and reduced operating costs. Employees also benefit from membership on a team. Team members find that working with a team can make their job easier and more satisfying. For example, team members provide for each other a source of energy, a "jump start" for their creativity, additional knowledge in their field, expertise in supplemental areas, a sounding board, and partners in decision-making and problem-solving.

Many chemical engineering problems are multifaceted and often require the expertise of various disciplines and different perspectives. Teams bring these diverse experiences and diverse banks of knowledge together. All the engineers on the team can access this diversity, which provides the foundation for better and more-creative solutions and decisions.

What makes a good team member? The key characteristic is that of active participation. Team membership is not a spectator sport. Everyone must play (their positions) or the team loses. Ten behaviors characteristic of a successful team member are highlighted in Table 1.

Though human beings are social animals and enjoy being part of a team or group, there is some hesitancy when first joining a team. Some of the questions that go through a new team member's mind at the first team meeting include: Who are these people? How do I fit in? Who is the person in charge? What am I supposed to do? These questions are normal and to be expected.

**Stages of team development**

Teams, whatever their purpose and make-up, go through stages of development during their existence, each of which is characterized by certain behaviors that reflect the team's stage of development. The five stages of development are (1):

- forming;
- storming;
- norming;
- performing; and
- adjourning.

**Table 1. A valuable and successful team member ...**

- ... listens.
- ... is open and honest.
- ... keeps promises and commitments.
- ... shares knowledge and experience.
- ... offers help to others before they ask.
- ... asks for ideas and suggestions.
- ... accepts suggestions and feedback.
- ... recognizes the value of others' viewpoints and ideas.
- ... has a "we" attitude.
- ... has a sense of humor.

**Forming stage.** This is a time of orientation. You aren't sure where you fit in or what is expected of you. When you become a member of a team, you may not know the other engineers very well or know where their talents or areas of expertise lie. Since you don't know them, you can't be sure your working styles will mesh. If the team leader doesn't know you well, there is the concern that he or she will not appreciate your experience and knowledge. You may even wonder if he or she knows anything about being a good team leader.

During the forming of the team, you may see any or all of the following behaviors demonstrated by team members:

- *polite and nonchallenging behavior* — as the team leader defines the goals and tasks of the team and assigns roles;
  - *feeling each other out* — trying to establish a comfort level with the various personalities;
  - *passivity of some members* — while they observe and try to get the "lay of the land";
  - *posturing of some members* — trying to impress the leader and other team members;
  - *uncertainty and apprehension* — as roles, assignments, and tasks are assigned; and
  - *excitement* — a feeling of being ready to tackle anything and everything.
- There are things that you can do to

help you and your team start its journey to becoming a real team. Ask questions to clarify goals, tasks, and roles. Ask silent members their opinions because the team needs their input. Volunteer for assignments and tasks so the leader and other members will become aware of your interests and your expertise. Volunteer to take minutes to help you focus your attention and listen effectively. And, get to know your teammates and leader — the better you know them, the easier it is to understand them and work with them.

**Storming stage.** To evolve to the next stage, the team members must give up the safety of the polite atmosphere that exists during the forming stage and risk conflict. Teams go through a period of discontent, and this is called the storming stage.

During the storming stage you are likely to see the following behaviors:

- *jockeying for position* — to become the recognized informal leader;
- *formation of subgroups and coalitions* — attempting to influence the leader and each other;
- *challenging of the leader* — goals, direction, tasks, and even expertise may be questioned;
- *judging and evaluating* — of other team members' opinions and ideas;
- *avoiding of tasks* — as the novelty of being on a team wears off; and
- *interrupting and talking over each other* — trying to establish credibility with volume instead of facts and logic.

During this difficult stage of team development, you must make a conscious effort to examine your own behaviors. Identify and challenge ineffective behaviors; for example, politely and calmly request that only one person talk at a time, because you're having difficulty hearing all the points that are being made. Actively listen; ask clarifying questions and paraphrase responses to ensure understanding. Confront problems in a timely manner, since problems and conflicts usually don't go away but get worse with time. Calmly state the situ-

ation as you see it, and after you have presented your position, ask the other person for his or her thoughts. Look for areas of agreement when there is a conflict and build on those to reach a win-win agreement. Finally, don't be afraid to be wrong or say that you don't know something. The goal of the team is to work together effectively.

During the storming stage of team development, it is important for team members to state what they feel as well as what they think. Team members need to know when a member is feeling frustrated, angry, hurt, or overwhelmed. When team members are experiencing negative emotions, it can reduce their productivity and color their perspective. Expressing feelings opens the door to communication and the evolution of the team to the next stage.

**Norming stage.** For a team to move forward to the norming stage, team members must move from that testing and proving mentality to a problem-solving mentality. The most important skill team members need for the team to move on is the ability to listen — to each other, to the team leader, and the team leader to the team. During the norming stage, members have fun together as they begin handling problems and making decisions.

During this stage you may experience the following:

- *meetings settle into a routine* — since team members are comfortable with their roles and responsibilities;

- *fewer power plays and less grandstanding* — there is a "we" attitude instead of an "us against them" feeling; and

- a "*don't want to rock the boat*" mentality — for fear of starting new conflicts.

Here, you should: Challenge the routine to avoid falling into a rut. Address undercurrents and hidden agendas before they become full-blown conflicts. Ask for additional responsibilities, as an individual and as a team, to encourage growth.

**Performing stage.** The fourth stage of development is called performing. A

team at this stage is operating at its peak. This is the stage that all teams strive for. During this stage, the roles are clear and each person's contribution is distinct. There is open discussion and acceptance of differences. The members take the initiative, as well as challenge one another's ideas, and the challenges lead to creative problem-solving. Members are able to seek feedback from one another and from the team leader on ways to improve their effectiveness and the team's.

You may see such behaviors as:

- *self-confidence* — opinions and ideas are freely shared;

- *constructive disagreement* — ideas, not people, are challenged;

- *high-level creativity* — risk-taking is encouraged;

- *mutual trust* — team members tell the truth; and

- *all appropriate decisions are made by consensus* — when there is a need for a high-quality decision and strong commitment in the implementation.

Members of a team that has reached the performing stage may feel that they have climbed the mountain and have successfully met the challenges of becoming a team. The challenges, however, don't stop at the performing stage, because this stage, like all the previous ones, is not a solid and permanent one. Teams will ebb and flow between stages as the environment around them and from within changes. As new tasks and responsibilities are added and members come and go, the team members may find themselves backsliding to a previous stage. This is normal and to be expected.

When changes occur and the team finds itself backsliding into another stage, there are several things its members can do to help move the team forward again. The first is to acknowledge that the changes are impacting the team and that this is acceptable. Next, determine how the team is being impacted — is it experiencing a decline in participation, a lack of creativity or risk-taking, bickering among the members, or a sense of feeling adrift?

If so, team members should do the following. Continue to actively listen to fellow team members. Continue to clarify roles and responsibilities as necessary. Orient new team members by providing them with minutes of previous meetings. And, remind each other that backsliding is normal and that you will get past these difficulties.

**Adjourning stage.** The last stage for a team is called adjourning — the termination of the team. When your team disbands, there may be some apprehension. You and your teammates may not even be consciously aware of it. You will have been together for a period of time and will have come to depend upon one another while you work through problems and make decisions. Now, that support is being eliminated.

When a team disbands, it is a good idea to have some sort of closure. This can be as simple as a review of what the team has accomplished and an acknowledgment of everyone's participation by the team leader, or as elaborate as going out for a farewell dinner or lunch.

How long do these stages take? There is no one real answer to that question. Every team is different. The members, their experience, and commitment will vary.

What is known is that teams given enough time together will go through all the stages. A team with a finite time together, such as a project team, will start down the path of team development. How far they get will depend upon their understanding of team development, their team leader, and their commitment to making the team function effectively.

Though length of time spent in each stage varies, the following timeframes have been suggested (3):

- forming: 6-9 months;
- storming: 6-9 months;
- norming: 6-9 months; and
- performing: indefinite.

Further information about the stages of team development and team member and leader behaviors can be found in (4, 5).

## Improving your performance

So, you're on the team now and you want to be the best team member you can be. Here's a suggested ten-step action plan that will help you become a good team member. The steps are based on the ten characteristics of an effective team member.

Read through these ten steps and make a commitment to practice them. When you become more familiar with your team, you can supplement the commitment with specific actions or objectives. After practicing a while, ask your teammates for feedback on how well you are meeting your objectives.

1. *Practice active listening techniques.* Active listening requires that you pay attention to what is being said by other team members and not be thinking of what you are going to say next. There are a couple of effective techniques to help you. One is to jot down key phrases and who said them. This forces you to concentrate on what is being said and provides a "hook" to tie in your comments and ideas to what has been said previously. Another is to ask clarifying questions and paraphrase the responses to ensure your understanding. Both of these techniques help facilitate the development of trust and understanding within the team.

2. *Be open and honest, and don't agree just to avoid conflict.* Avoiding conflict is not conducive to the productivity of the team. You need to honestly state your objections and opinions on issues or you and your team may end up traveling down a road that no one really wants to explore.

Team members need to be told of behaviors that are negatively impacting the team's effectiveness and productivity. You can provide this feedback by describing specific behaviors and supplying examples of behaviors that may be more effective. Remember that it is the behavior, not the person, that is unacceptable.

3. *Keep promises and commitments and don't agree to do something you can't or won't be able to do.* Do yourself and your team a favor by checking calendars and honestly assessing commitments before saying yes. If there is a conflict, ask the team leader or management which task takes priority. If you don't have the necessary skills or knowledge to do the requested task, say so and ask for training or instruction.

4. *Ask for ideas and suggestions regarding the tasks that you're assigned.* In addition to asking engineers in your discipline and work group for input, ask other colleagues for ideas and suggestions. They may be able to provide a different perspective.

5. *Ask for feedback and suggestions regarding the effectiveness of your behavior as a team member.* Receiving feedback from fellow team members is critical to improving your team skills. Since you aren't deliberately trying to be ineffective, you need to know when what you are doing is not working. When you receive feedback, listen with an open mind, ask clarifying questions, and ask for specific examples. If you aren't given suggestions for improvement, ask for them. After you have received feedback, say "thank you" to that person, because they care enough about you and the team to risk the relationship.

6. *Offer help, and don't wait to be asked.* If you feel that someone could

use help or assistance in accomplishing a task, ask. You may find that the situation isn't as it appeared and no help is needed. Or, you may find you have just saved the day for a fellow team member who was reluctant to request help. Either way, you will have demonstrated the spirit of teamwork.

7. *Recognize the value of others' viewpoints and ideas even though you may not agree with them.* Acknowledge your fellow team members' participation. You don't have to agree with the context to acknowledge the spirit with which the ideas were put forth. Push past your initial disagreement and delve deeper by asking for facts and logic for changing your position. You may discover a new perspective for the problem.

8. *Share your knowledge and experience with team members.* Remember to always participate in meetings and discussions. Share your resources and related past experiences from previous companies and positions.

9. *Have a "we attitude" and think of what is good for the team, not just what is good for yourself.* Acknowledge the contributions of your team members to the accomplishment of tasks and projects to them directly and to management. Don't try to do everything yourself.

10. *Maintain a sense of humor even during stressful periods.* Teamwork takes work. Look for the humor in a situation and laugh at your own imperfections and idiosyncrasies.

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**P. L. PHILIPS** is the president of Philips Consulting, Inc., Pine Beach, NJ (908/505-0689; Fax: 908/505-0689; e-mail: Patricia.Philips@ASTD.Noli.com). She has 20 years of experience in training and technical writing as a corporate trainer and consultant. During the last six years she has specialized in the development of self-managed teams in the corporate environment. She has a BS in industrial relations and personnel administration from Rider Univ. in New Jersey. She holds memberships in the American Society of Training and Development, Society of Insurance Trainers and Educators, and New Jersey Association of Women Business Owners.