Appendix 3A

High School Appropriate Statics Tables

For

HIGH SCHOOL APPROPRIATE ENGINEERING CONTENT KNOWLEDGE IN THE INFUSION OF ENGINEERING DESIGN INTO K-12 CURRICULUM

(Under the General Topic of "Engineering Design in Secondary Education" and of "Vision and Recommendations for Engineering-Oriented Professional Development")

Summer 2009 (Completion Date: Thursday, July 9, 2009)

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Notes on How to Use This Appendix

The whole Research Project and this Appendix constitute the groundwork for a proposed four-round five-point Likert Scale survey study, with five major steps in its research design:

1. Preliminary selection of high school appropriate statics topics;
2. Presentation of data to faculty advisors for review;
3. Presentation of data to a panel of university faculty for validation and endorsement;
4. 4-round Delphi study using 5-point Likert Scale;
5. Comparative analysis of the results from the 4-round Delphi study, for the creation of a formal list of high school appropriate engineering topics.

Participants in the "4-round Delphi study using 5-point Likert Scale" might include the following groups of stakeholders in engineering and technology education:

- Group 1 (University Engineering and Technology Faculty);
- Group 2 (University K-12 Technology Education Faculty);
- Group 3 (University Undergraduate Senior-Year Engineering Students);
- Group 4 (K-12 Technology and STEM Teachers and Administrators);
- Group 5 (Practicing Engineers and Technicians).

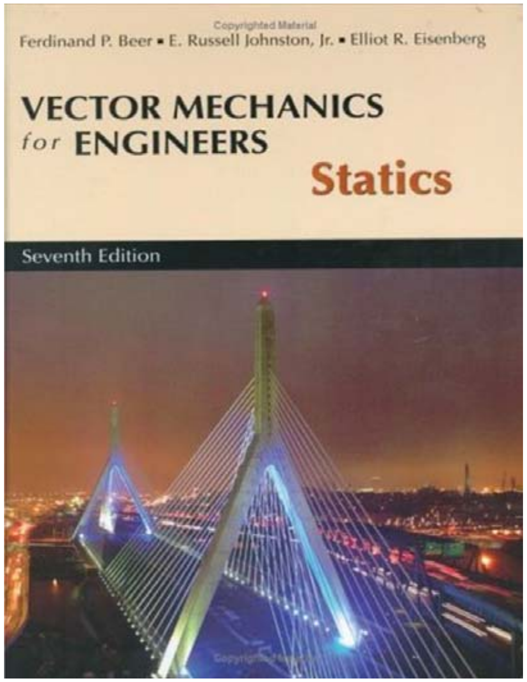


Figure 1A. The main textbook where the Statics related engineering analytic and predictive principles and computational formulas are extracted.

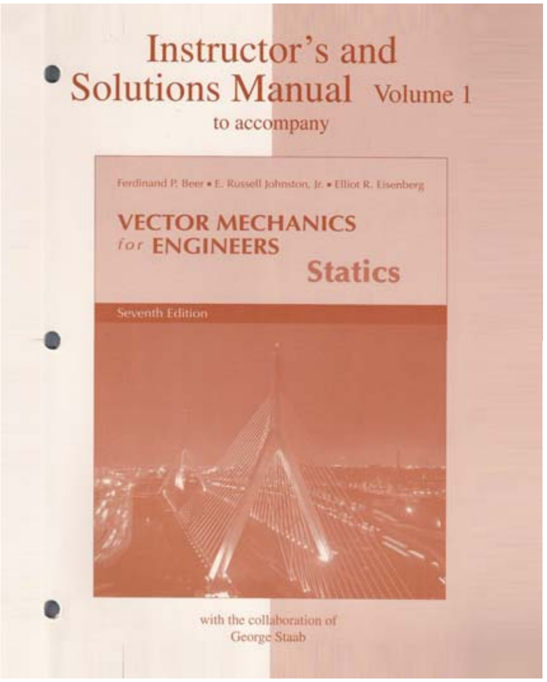


Figure 1C. The Volume 1 of the Instructor's and Solutions Manual for the main textbook used to double-check for the mathematics and physics principles and computational skills needed for the study of various topics of statics contained in the main textbook.

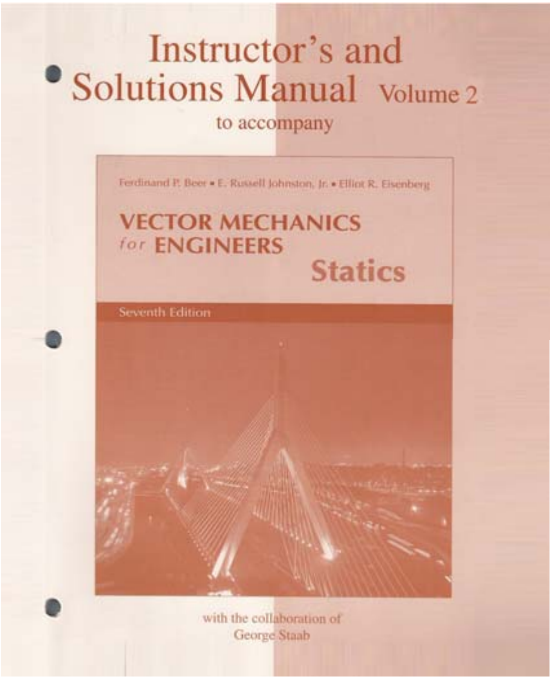


Figure 1C. The Volume 2 of the Instructor's and Solutions Manual for the main textbook used to double-check for the mathematics and physics principles and computational skills needed for the study of various topics of statics contained in the main textbook.

Textbook Information

	Main Textbook	Instructor's Solution Manuals	
Title	Vector Mechanics for Engineers Statics, 7th Edition	Instructor's and Solutions Manual to Accompany Vector Mechanics for Engineers – Statics, 7th Edition, Volume 1	Instructor's and Solutions Manual to Accompany Vector Mechanics for Engineers – Statics, 7th Edition, Volume 2
Authors	Ferdinand P. Beer & E. Russell Johnston & Elliot R. Eisenberg	Ferdinand P. Beer & E. Russell Johnston & Elliot R. Eisenberg	Ferdinand P. Beer & E. Russell Johnston & Elliot R. Eisenberg
Publisher	McGraw-Hill Higher Education	McGraw-Hill Higher Education	McGraw-Hill Higher Education
Year	2004	2004	2004
ISBN	0-07-230493-6	10: 0072536055	10: 0072962623

This Appendix contains tabulated information on the initial determination of high school (at 9th Grade level) appropriate engineering analytic and predictive principles and computational formulas for the subject of statics; this determination is based on the satisfaction of pre-requisite mathematics and science (namely, physics) education, as mandated by Georgia Performance Standards established by the State of Georgia Department of Education (available at https://www.georgiastandards.org/Pages/Default.aspx). The above-mentioned principles and computational formulas have been extracted from one of the most popular university undergraduate lower-division textbook on statics; associated reference books have been used as well (see *Figures 1A*, *1B*, and *1C*). The Appendix contains the following:

- **Part One – Initial Determination of High School (9th Grade) Appropriate Statics Topics**: This Part covers the 1st, 2nd and 3rd of the above-listed 5 major steps of the proposed study (i.e., "preliminary selection of high school appropriate engineering topic," "presentation of data to faculty advisors for review," and "presentation of data to a panel of university faculty for validation and endorsement"); and it contains the *Statics Topic List (Engineering Topics Mathematics and Science Pre-requisite Completion Chart for the Subject of Statics)*, on pages 14-36. As shown in *Figures 2A* and *2B*, on the tabulated list, the columns listing the mathematics and physics pre-requisites for the study of each statics topic are listed on the right of the column containing the titles of the chapters and sections with associated formulas, which are symbolic representations of engineering analytic and predictive principles. The list will serve two purposes:

1. **<u>For data review and validation</u>**: The list will be submitted to Dr. Robert Wicklein, Dr. John Mativo, and Dr. Roger Hill at the College of Education, the University of Georgia, for review, and for validation of the findings at technical level, in terms of validity of pre-requisite sequence and of high school students' preparedness for learning the engineering knowledge content identified therein. Dr. Robert Wicklein is a veteran educator profoundly and broadly experienced in teaching both K-12 and university students engineering design and technology. Dr. John Mativo has strong academic background and long history of professional practice in both mechanical and electrical engineering, and over 15 years of working experience in university engineering instruction as well as in the development of K-12 appropriate engineering curriculum. Dr. Roger Hill is a veteran professor in the area of workforce education and is very knowledgeable about K-12 education process. All of them possess great expertise in making judgment on the feasibility of infusing specific engineering knowledge content into K-12 curriculum. To facilitate such review and validation, proposed procedures are available on pages 8-13. After Dr. Robert Wicklein, Dr. Roger Hill and Dr. John Mativo complete the review and validation process, the list would be edited to make corrections to all possible errors and mistakes; and if necessary and possible, the corrected list might be submitted to a panel of university faculty for additional validation and endorsement; and the potential members of this panel would be selected among engineering processors with experience teaching statics course for at least three semesters in an ABET-accredited undergraduate engineering program, from four-year universities granting master's and/or doctoral degrees in mechanical and civil engineering.

2. **<u>As part of the 1st round of the proposed four-round five-point Likert Scale Delphi study</u>**: The expert opinions on the relative importance of each topic of statics (with analytic principles and computational formulas), collected from the review and validation process conducted by the above professors will be counted as part of the data for the first round of the Delphi study and statistically analyzed and processed accordingly, so as to prepare for the second round of the proposed Delphi survey with the above-mentioned five Groups of Participants.

- **<u>Part Two – 1st Round of Delphi - Five-Point Likert Scale Survey Forms</u>**: This Part prepares for the 4th of the above-listed 5 major steps of the proposed study; and it contains two survey forms (i.e., the first round of the "4-round Delphi study using 5-point Likert Scale"). The Survey Forms will be presented to the above-mentioned five Groups of Participants for the first round of the proposed Delphi survey. To facilitate the survey, detailed information on how to fill out survey forms are available on pages 37-43.

1. *Statics Survey Form A (1st Round of Delphi - Likert Scale Questionnaire on the Importance of Various Statics Topics Selected for High School Engineering Curriculum (For the Pre-calculus Portion)*: As the name implies, this list covers only the statics topics with computational formulas requiring no calculus related skills. (pp. 44-52).

2. *Statics Survey Form B (Delphi - Likert Scale Questionnaire on the Importance of Various Statics Topics Selected for High School Engineering Curriculum (For the Calculus Portion)*: As the name implies, this list covers only the statics topics with computational formulas requiring calculus related skills. (pp. 53-64).

- **Part Three – Findings from the Research Project**: This Part contains tabulated lists showing the results of this research project, which might be used as reference in the future endeavors to infuse statics related engineering analytic and predictive principles and computational skills into a potentially viable high school engineering and technology curriculum, which shall be based on the organic and seamless integration of solid mastery of engineering analytic and predictive principles and innovative application of engineering design process.

    - *List 1A. Pre-Calculus Based Statics Topics That Possibly Could Be Taught at 9th Grade*: The statistic summary of data at the end of this list (p. 69) indicates that a significant portion of statics knowledge content covered in the selected undergraduate level textbook could possibly be taught to high school students. 58.7% of all Sections, and 56.0% of the volume in the selected textbook is based on pre-calculus mathematics and on principles of physics students are supposed to learn before or by 9th Grade, according to Georgia Performance Standards (p. 69).

    - *List 1B. Pre-Requisite Mathematics and Science Topics to Be Reviewed Before Teaching the Pre-Calculus Portion of Statics Topics to 9th Grade Students*: This list includes 16 sets of mathematics principles and skills, as well as7 sets of physics principles and skills that are needed as pre-requisites or as important topics to be reviewed for the effective learning of statics topics initially determined as appropriate for 9th Grade students (p. 171).

    - *List 2A. Calculus Base Statics Topics for Post-Secondary Engineering Education*: Topics of statics on this list are either recommended for post-secondary engineering education, or for inclusion as application problems in 11th or 12th Grade Advanced Placement Calculus course (p. 71).

    - *List 2B. Pre-Requisite Math and Science Topics to Be Reviewed Before Teaching the Calculus Portion of Statics Topics*: This list includes 33 sets of mathematics principles and skills, as well as 10 sets of physics principles and skills that are needed as pre-requisites or as important topics to be reviewed for the effective learning of statics topics initially recommended either for university engineering students or for high school 11th or 12th Grade students enrolled in Advanced Placement Calculus courses (p. 72).

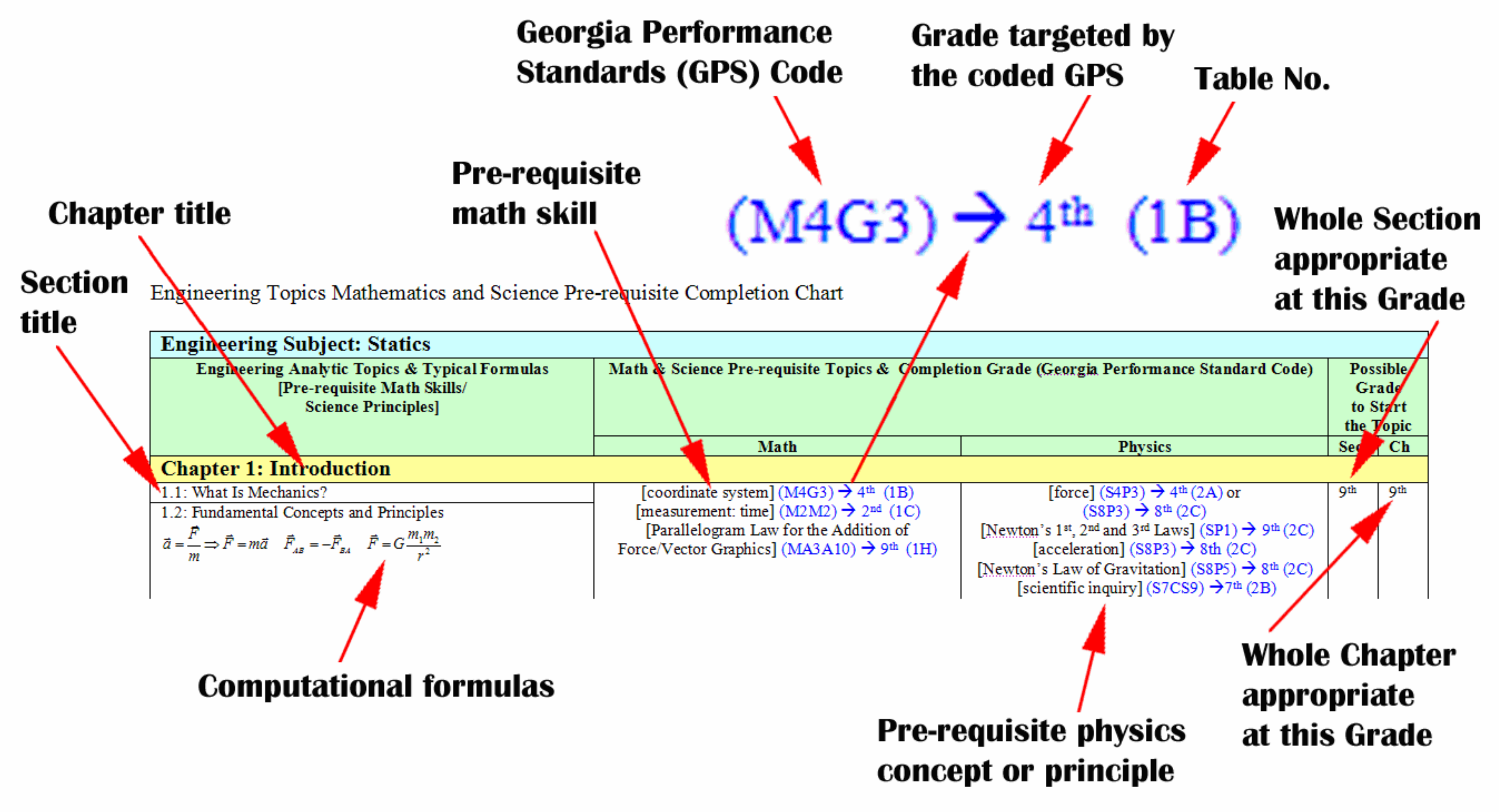


Figure 2A. Engineering Topics Mathematics and Science Pre-requisite Completion Chart for the Subject of Statics.

Engineering Subject: Statics				
Engineering Analytic Topics & Typical Formulas [Pre-requisite Math Skills/ Science Principles]	**Math & Science Pre-requisite Topics & Completion Grade (Georgia Performance Standard Code)**		**Possible Grade to Start the Topic**	
	Math	**Physics**	**Sec**	**Ch**
Chapter 8: Friction (Continued)				
8.10: Belt Friction $\ln\frac{T_2}{T_1} = \mu_s\beta \quad \frac{T_2}{T_1} = e^{\mu_s\beta}$ (For other formulas, refer to pp. 451-452)	[summation/addition] (M6N1) → 6th (2A) [four operations] (M1N3) → 1st (2A) + (M2N3) → 2nd (2A), or (M7N1) → 7th (2A) [trigonometric functions] (MA2G2) → 10th (2F) → To be taught as a special math topic [logarithmic functions] (MA2A4) → 10th (2E) → To be taught as a special math topic [integration] → 12th (to be taught) [differentiation] → 12th (to be taught)	[force] (S4P3) → 4th (3A) or (S8P3) → 8th (3C)	PS	PS

Integration and differentiation covered at Grade 12

Whole chapter apropriate for university undergraduate statics course

Figure 2B. Notation for undergraduate level appropriate statics topics.

Part One: Initial Determination of High School (9th Grade) Appropriate Statics Topics

Proposed Procedures for Review and Validation

To facilitate review and validation of the initial selection of statics topics that could be possibly taught to students at 9th or above Grade, as listed in the *Statics Topic List*, the following procedures are hereby proposed:

1. Look at the formulas listed under the **Engineering Analytic Topics & Typical Formulas** column, and check the mathematics and science pre-requisite items under the **Math** and **Physics/Chemistry** columns; verify if there are necessary pre-requisite that are missing; if so, write a note in either the **Math** or **Physics/Chemistry** column; and if any listed item is not really needed, cross it out with a horizontal strikethrough (as shown on *Figure 3A*);

2. Rate the importance of each Section as a topic in a potentially viable 9th or above Grade statics subject, and write a number representing its “importance” value (*Figure 3A*), using the five-point Likert Scale (*Figure 3B*);

3. Check the formulas listed under the **Engineering Analytic Topics & Typical Formulas** column, and use symbols shown in *Figure 3B* to indicate your expert opinion and advice about each formula;

4. Add your comment and advice on the Grade at which the topic should be taught to pre-collegiate students;

5. Add your general comments and advice in the empty space.

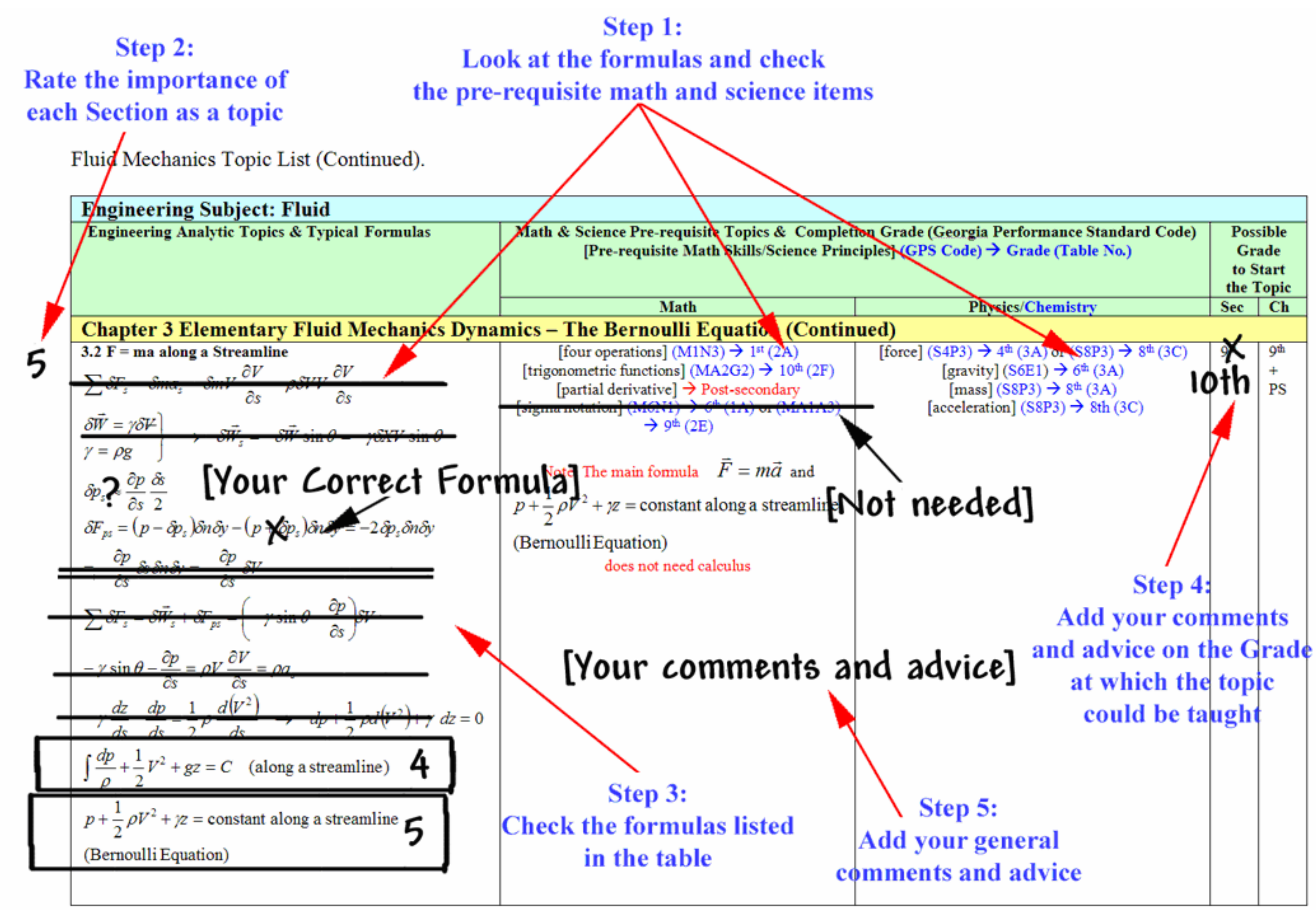


Figure 3A. Step-by-step procedures proposed for the review and validation of data.

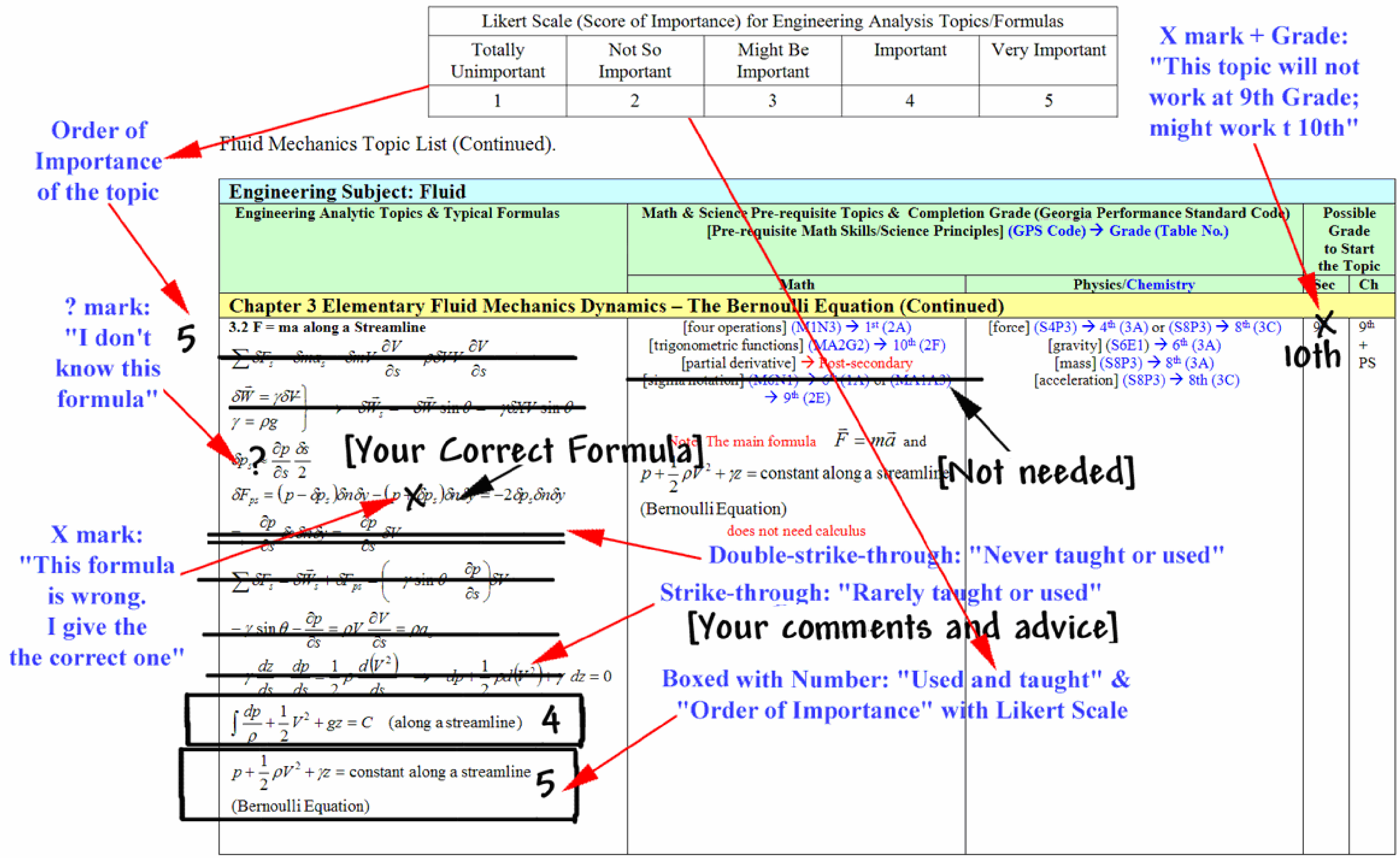


Figure 3B. Likert Scale (top) and symbols to be used for the expression of expert opinion and offer of advice.

Notes about the Statics Analytic Principles and Formulas

The leftmost column in the *Statics Topic List (Engineering Topics Mathematics and Science Pre-requisite Completion Chart for the Subject of Statics)* contains

1. The titles of each section under a particular chapter in the selected textbook, which in general represent particular sets of statics related engineering analytic and predictive principles, in a qualitative and explanatory way;

2. Computational formulas, which symbolically represent the above engineering analytic and predictive principles, in a quantitative and mathematical way.

As shown in *Figure 3B*, the formulas extracted from the selected textbook might by categorized into five groups, corresponding to the five different symbols shown in *Figure 3B*, which could be used by the above-mentioned professors from the University of Georgia and other schools to indicate their expert opinions and advices about each formula:

1. <u>Formulas that engineering professors actually teach in classroom lectures and that practicing engineers use in engineering design projects</u>: These are the important ones to be included in a potentially viable K-12 engineering curriculum that shall be based on cohesive and systemic mastery of engineering analytic and predictive principles and skills. For any of these formulas, a box could be used together with a number representing its order of importance according to the five-point Likert Scale (1 = Totally Unimportant, 2 = Not So Important, 3 = Might Be Important, 4 = Important, or 5 = Very Important).

2. <u>Formulas that are rarely used in either classroom lectures or in field practice, but are used by the original discoverer of a particular set of analytic principles to derive other formulas that are actually used in classroom lecture or in field practice</u>: Some of these “intermediate” formulas might not be used often, in other words, they are “rarely taught or used.” For any of these formulas, a strikethrough could be used. If a big enough percentage of participants (maybe 85% or above) place a strikethrough on a particular formula at the end of each round of the proposed four-round Delphi study, then the formula will be removed from the survey form for the next round. If the trend continues through all four rounds of the proposed Delphi survey, then that formula might be removed from the final list of high school appropriate statics topics. Interestingly enough, in some cases, rarely used calculus-based “intermediate” formulas are used to derive a final one that is based on

pre-calculus mathematics skills and is actually used in most homework assignments and design projects; in this case, if the "intermediate" formulas are removed from consideration, then the entire topic of fluid mechanics could be re-classified as appropriate for 9th Grade. For example, in fluid mechanics, the main formula $\vec{F} = m\vec{a}$ and $p + \frac{1}{2}\rho V^2 + \gamma z =$ constant along a streamline (Bernoulli Equation) do not need calculus, and thus, could be taught to 9th Grade students. This type of formulas will make the list shorter and shorter as the proposed Delphi study moves to the next round of survey. Some of these formulas might not be in the selected textbook; I derived them for fun, sometimes with the help of my former engineering professor, Dr. Samuel Landsberger, at California State University Los Angeles.

3. <u>Formulas that are particular to certain conditions and in real classroom lectures or field practice are, for all practical purposes, are close to be "never used</u>:" For any of these formulas, a double-strikethrough could be used. If a big enough percentage of participants (maybe 75% or above) place a double-strikethrough on a particular formula at the end of each round of the proposed four-round Delphi study, then the formula will be removed from the survey form for the next round. If the trend continues through all four rounds of the proposed Delphi survey, then that formula might be removed from the final list of high school appropriate statics topics. This type of formulas will also make the list shorter and shorter as the proposed Delphi study moves to the next round of survey.

4. <u>Formulas that even experienced university engineering professors or practicing engineers might "not understand</u>:" This is amazing but totally correct and yes, absolutely normal! There are formulas that even experienced professors might say "I do not understand this" or "I need to read the context in the book to figure this out." For any of these formulas, the participants should generally not seek to understand them (doing so does not serve the purpose of studying the relative importance of each computational formula); but instead, a question mark (?) could be used. If a big enough percentage of participants (maybe 65% or above) place a question mark (?) on a particular formula at the end of each round of the proposed four-round Delphi study, then the formula will be removed from the survey form for the next round. If the trend continues through all four rounds of the proposed Delphi survey, then that formula might be removed from the final list of high school appropriate statics topics. Indeed, it makes little sense to include this type of formulas to a potentially viable K-12 engineering curriculum. This type of formulas will also make the list shorter and shorter as the proposed Delphi study moves to the next round of survey. Some of these formulas might not be in the selected textbook; I derived them for fun, sometimes with the help of my former engineering professor, Dr. Samuel Landsberger, at California State University Los Angeles.

5. Formulas that are wrong for any reasons (my typing errors, or the authors' errors, etc.): For any of these formulas, a cross (X) could be used and the correct formulas should be given if possible. The correction would be included in the survey forms for the subsequent rounds of the four-round five-point Likert Scale Delphi study.

For convenience of statistic analysis of expert opinions and advice, it is requested that all participants print each letter of their comment legibly and separately, using fonts commonly used in engineering notebooks.

Statics Topics List
Engineering Topics Mathematics and Science Pre-requisite Completion Chart for the Subject of Statics

Engineering Subject: Statics				
Engineering Analytic Topics & Typical Formulas	**Math & Science Pre-requisite Topics & Completion Grade (Georgia Performance Standard Code)** **[Pre-requisite Math Skills/Science Principles] (GPS Code) → Grade (Table No.)**		**Possible Grade to Start the Topic**	
	Math	**Physics**	**Sec**	**Ch**
Chapter 1: Introduction				
1.1: What Is Mechanics? **1.2: Fundamental Concepts and Principles** $\vec{a} = \frac{\vec{F}}{m} \Rightarrow \vec{F} = m\vec{a}$ $\quad \vec{F}_{AB} = -\vec{F}_{BA}$ $\quad \vec{F} = G\frac{m_1 m_2}{r^2}$	[coordinate system] (M4G3) → 4th (2B) [measurement: time] (M2M2) → 2nd (2C) [Parallelogram Law for the Addition of Force/Vector Graphics] (MA3A10) → 11th (2H) → To be taught as a special math topic	[force] (S4P3) → 4th (3A) or (S8P3) → 8th (3C) [Newton's 1st, 2nd and 3rd Laws] (SP1) → 9th (3C) [acceleration] (S8P3) → 8th (3C) [Newton's Law of Gravitation] (S8P5) → 8th (3C) [scientific inquiry] (S7CS9) →7th (3B)	9th	9th
1.3: Systems of Units **1.4: Conversion from One System of Units to Another**	[unit conversion] (M6M1) → 6th (2C)	N/A	6th	
1.5: Method of Problem Solution	[problem-solving] (M3N5) → 3rd (2A)	N/A	3rd	
1.6: Numerical Accuracy	[percent] (M5N5) → 5th (2A)	N/A	5th	
Chapter 2: Statics of Particles				
2.1: Introduction **<u>Forces in a Plane</u>** **2.2: Force on a Particle. Resultant of Two Forces**	[four operations] (M1N3) → 1st (2A) + (M2N3) → 2nd (1A), or (M7N1) → 7th (2A) [coordinate system] (M4G3) → 4th (2B)	[force] (S4P3) → 4th (3A)	4th	9th
2.3: Vectors **2.4: Addition of Vectors** **2.5: Resultant of Several Concurrent Forces**	[vector graphics] (MA3A10) → 9th (2H) → To be taught as a special math topic	[force] (S4P3) → 4th (3A) or (S8P3) → 8th (3C)	9th	
2.6: Resolution of a Force into Components **2.7: Rectangular Components of a Force. Unit Vectors**	[vector graphics] (MA3A10) → 9th (2H) [trigonometric functions] (MA2G2) → 9th (2F)	[force] (S4P3) → 4th (3A) or (S8P3) → 8th (3C)	9th	
2.8: Addition of Forces by Summing *x* and *y* Components $\vec{F} = F_x\hat{i} + F_y\hat{j} \quad F_x = F\cos\theta$ $F_y = F\sin\theta \quad \tan\theta = \frac{F_y}{F_x} \quad F = \sqrt{F_x^2 + F_y^2}$	[four operations] (M1N3) → 1st (2A) + (M2N3) → 2nd (2A), or (M7N1) → 7th (2A) [square root] (M8N1) → 8th (2A) [trigonometric functions] (MA2G2) → 10th (2F) → To be taught as a special math topic [coordinate system] (M4G3) → 4th (2B)	[force] (S4P3) → 4th (3A) or (S8P3) → 8th (3C)	8th	
2.9: Equilibrium of a Particle $R = \sum F = F_1 + F_2 + ... = 0 \quad \Rightarrow \quad R_x = \sum F_x = 0 \quad R_y = \sum F_y = 0$ $R_z = \sum F_z = 0$	[sigma notation] (M6N1) → 6th (1A) or (MA1A3) → 9th (2E) → To be taught as a special math topic [four operations] (M1N3) → 1st (2A) + (M2N3) → 2nd (1A), or (M7N1) → 7th (2A)	[force] (S4P3) → 4th (3A) or (S8P3) → 8th (2C)	9th	

Statics Topics List (Continued).

Engineering Subject: Statics				
Engineering Analytic Topics & Typical Formulas	**Math & Science Pre-requisite Topics & Completion Grade (Georgia Performance Standard Code)** **[Pre-requisite Math Skills/Science Principles] (GPS Code) → Grade (Table No.)**		**Possible Grade to Start the Topic**	
	Math	**Physics**	**Sec**	**Ch**
Chapter 2: Statics of Particles (Continued)				
2.10: Newton's First Law of Motion **2.11: Problems Involving the Equilibrium of a Particle. Free-Body Diagrams**	[four operations] (M1N3) → 1^{st} (2A) + (M2N3) → 2^{nd} (1A), or (M7N1) → 7^{th} (2A)	[Newton's 1^{st}, 2^{nd} and 3^{rd} Laws] (SP1) → 9^{th} (3C) [acceleration] (S8P3) → 8th (3C)	9^{th}	9^{th}
<u>Forces in Space</u> **2.12: Rectangular Components of a Force in Space** $F_y = F\cos\theta_y \quad F_h = F\sin\theta_y$ $F_x = F_h\cos\phi = F\sin\theta_y\cos\phi \quad F_z = F_h\sin\phi = F\sin\theta_y\sin\phi$ $F^2 = F_y + F_h = F_y + F_x + F_z \quad \rightarrow \quad F = \sqrt{F_x + F_y + F_z}$ $F_x = F\cos\theta_x \quad F_y = F\cos\theta_y \quad F_z = F\cos\theta_z \quad (0^\circ < \theta_{x,y,z} < 180^\circ)$ $\vec{F} = F_x\hat{i} + F_y\hat{j} + F_z\hat{k}$ $\vec{F} = F\left(\cos\theta_x\hat{i} + \cos\theta_y\hat{j} + \cos\theta_z\hat{k}\right)$ $\cos\theta_x = \frac{F_x}{F} = \frac{d_x}{d} = \frac{R_x}{R} \quad \cos\theta_y = \frac{F_y}{F} = \frac{d_y}{d} = \frac{R_y}{R} \quad \cos\theta_z = \frac{F_z}{F} = \frac{d_z}{d} = \frac{R_z}{R}$ $\theta_{x(y,z)} = \cos^{-1}\frac{F_{x(y,z)}}{F} = \cos^{-1}\frac{d_{x(y,z)}}{d} \quad F = \sqrt{F_x^2 + F_y^2 + F_z^2}$ $\hat{\lambda} = \cos\theta_x\hat{i} + \cos\theta_y\hat{j} + \cos\theta_z\hat{k} \quad \hat{\lambda} = \frac{\vec{F}}{F} \quad \hat{i} = \frac{d_x}{d} \quad \hat{j} = \frac{d_y}{d} \quad \hat{k} = \frac{d_z}{d}$ $\cos^2\theta_x + \cos^2\theta_y + \cos^2\theta_z = 1 \quad \rightarrow \quad \hat{\lambda}_x^2 + \hat{\lambda}_y^2 + \hat{\lambda}_z^2 = 1$	[four operations] (M1N3) → 1^{st} (2A) + (M2N3) → 2^{nd} (1A), or (M7N1) → 7^{th} (2A) [square root] (M8N1) → 8^{th} (2A) [trigonometric functions] (MA2G2) → 10^{th} (2F) → To be taught as a special math topic [coordinate system] (M4G3) → 4^{th} (2B)	[force] (S4P3) → 4^{th} (3A) or (S8P3) → 8^{th} (3C)	9^{th}	

Statics Topics List (Continued).

Engineering Subject: Statics				
Engineering Analytic Topics & Typical Formulas	**Math & Science Pre-requisite Topics & Completion Grade (Georgia Performance Standard Code)** **[Pre-requisite Math Skills/Science Principles] (GPS Code) → Grade (Table No.)**		**Possible Grade to Start the Topic**	
	Math	**Physics**	**Sec**	**Ch**
Chapter 2: Statics of Particles (Continued)				
2.13: Force Defined by Its Magnitude and Two Points on Its Line of Action $\overrightarrow{MN} = d_x\hat{i} + d_y\hat{j} + d_z\hat{k}$ $\hat{\lambda} = \frac{\overrightarrow{MN}}{MN} = \frac{1}{d}\left(d_x\hat{i} + d_y\hat{j} + d_z\hat{k}\right)$ $d_{x(y,z)} = x(y,z)_2 - x(y,z)_1 \quad d = \sqrt{d_x^2 + d_y^2 + d_z^2}$ $\vec{F} = F\hat{\lambda} = \frac{F}{d}\left(d_x^2\hat{i} + d_y^2\hat{j} + d_z^2\hat{k}\right)$ $F_x = \frac{Fd_x}{d} \quad F_y = \frac{Fd_y}{d} \quad F_z = \frac{Fd_z}{d}$	[four operations] (M1N3) → 1st (2A) + (M2N3) → 2nd (1A), or (M7N1) → 7th (2A) [square root] (M8N1) → 8th (1A) [trigonometric functions] (MA2G2) → 10th (2F) → To be taught as a special math topic [coordinate system] (M4G3) → 4th (2B)	[force] (S4P3) → 4th (3A) or (S8P3) → 8th (3C) [Newton's 1st, 2nd and 3rd Laws] (SP1) → 9th (3C)	9th	9th
2.14: Addition of Concurrent Forces in Space $\vec{R} = \sum \vec{F} \quad R = \sqrt{R_x^2 + R_y^2 + R_z^2}$ $R_x\hat{i} + R_y\hat{j} + R_z\hat{k} = \left(\sum F_x\right)\hat{i} + \left(\sum F_y\right)\hat{j} + \left(\sum F_z\right)\hat{k}$	[four operations] (M1N3) → 1st (2A) + (M2N3) → 2nd (1A), or (M7N1) → 7th (2A) [square root] (M8N1) → 8th (2A) [trigonometric functions] (MA2G2) → 10th (2F) → To be taught as a special math topic [coordinate system] (M4G3) → 4th (2B)	[force] (S4P3) → 4th (3A) or (S8P3) → 8th (3C) [Newton's 1st, 2nd and 3rd Laws] (SP1) → 9th (3C)	9th	
2.15: Equilibrium of a Particle in Space $R = \sum F = F_1 + F_2 + \ldots = 0 \;\rightarrow\; R_x = \sum F_x = 0 \quad R_y = \sum F_y = 0 \quad R_z = \sum F_z = 0$ $\begin{bmatrix} a & b & c \\ d & e & f \\ g & h & i \end{bmatrix} \times \begin{bmatrix} x \\ y \\ z \end{bmatrix} = \begin{bmatrix} ax+by+cz \\ dx+ey+fz \\ gx+hy+iz \end{bmatrix} \quad \begin{bmatrix} a & b & c \\ d & e & f \\ g & h & i \end{bmatrix} \times \begin{bmatrix} F_1 \\ F_2 \\ F_3 \end{bmatrix} = \begin{bmatrix} 0 \\ 0 \\ 0 \end{bmatrix}$ $R_x = \sum F_x = 0 \quad aF_1 + bF_2 + cF_3 = 0$ $R_y = \sum F_y = 0 \quad dF_1 + eF_2 + fF_3 = 0$ $R_z = \sum F_z = 0 \quad gF_1 + hF_2 + iF_3 = 0$ $\begin{bmatrix} a & b & c \\ d & e & f \\ g & h & i \end{bmatrix} \times \begin{bmatrix} F_1 \\ F_2 \\ F_3 \end{bmatrix} = \begin{bmatrix} aF_1 + bF_2 + cF_3 \\ dF_1 + eF_2 + fF_3 \\ gF_1 + hF_2 + iF_3 \end{bmatrix}$	[coordinate system] (M4G3) → 4th (2B) [four operations] (M1N3) → 1st (2A) + (M2N3) → 2nd (1A), or (M7N1) → 7th (2A) [linear algebra](MA2A6) (MA2A7) (MA2A8) (MA2A9) → 10th (2G) → To be taught as a special math topic	[force] (S4P3) → 4th (3A) or (S8P3) → 8th (3C) [Newton's 1st, 2nd and 3rd Laws] (SP1) → 9th (3C)	9th	

Statics Topics List (Continued).

Engineering Subject: Statics				
Engineering Analytic Topics & Typical Formulas	**Math & Science Pre-requisite Topics & Completion Grade (Georgia Performance Standard Code)** **[Pre-requisite Math Skills/Science Principles] (GPS Code) → Grade (Table No.)**		**Possible Grade to Start the Topic**	
	Math	**Physics**	**Sec**	**Ch**
Chapter 3: Rigid Bodies - Equivalent Systems of Forces				
3.1: Introduction **3.2: External and Internal Forces** **3.3: Principle of Transmissibility. Equivalent Forces**	[four operations] (M1N3) → 1st (2A) + (M2N3) → 2nd (2A) [geometry: point, axis/line, 3D body] (M6G1) (M6G2) (M6M3) → 6th (2B)	[force] (S4P3) → 4th (3A) [motion] (SKP2) → K (3A)	6th	9th
3.4: Vector Product of Two Vectors $\vec{V} = \vec{P}\times\vec{Q}$ $V = PQ\sin\theta$ $\vec{V}\perp\vec{P}$ $\vec{V}\perp\vec{Q}$ $\vec{V}\perp Plane_{\vec{P},\vec{Q}}$ $\vec{P}\times(\vec{Q}_1+\vec{Q}_2)=\vec{P}\times\vec{Q}_1+\vec{P}\times Q_2$ $(\vec{P}\times\vec{Q})\times\vec{S}\neq\vec{P}\times(\vec{Q}\times\vec{S})$ $\vec{V}=\vec{Q}\times\vec{P}=-(\vec{P}\times\vec{Q})$ $\vec{Q}\times\vec{P}\neq\vec{P}\times\vec{Q}$ $\vec{P}\times\vec{Q}=-\vec{V}$ $\vec{P}\times(\vec{Q}_1+Q_2)=\vec{P}\times\vec{Q}_1+\vec{P}\times Q_2$ $\vec{Q}\times\vec{P}\neq\vec{P}\times\vec{Q}$ $\vec{V}=\vec{Q}\times\vec{P}=-(\vec{P}\times\vec{Q})$ $\vec{P}\times\vec{Q}=-\vec{V}$ $\vec{V}=\vec{P}\times\vec{Q}$ $(\vec{P}\times\vec{Q})\times\vec{S}\neq\vec{P}\times(\vec{Q}\times\vec{S})$	[trigonometric functions] (MA2G2) → 10th (2F) → To be taught as a special math topic [cross product] → To be taught as a special math topic	[force] (S4P3) → 4th (3A) or (S8P3) → 8th (3C) [motion] (SKP2) → K (3A)	9th	
3.5: Vector Products Expressed in Terms of Rectangular Components $\hat{i}\times\hat{i}=\hat{j}\times\hat{j}=\hat{k}\times\hat{k}=0$ $\hat{i}\times\hat{j}=\hat{k}$ $\hat{j}\times\hat{k}=\hat{i}$ $\hat{k}\times\hat{i}=\hat{j}$ $\hat{i}\times\hat{k}=-\hat{j}$ $\hat{j}\times\hat{i}=-\hat{k}$ $\hat{k}\times\hat{j}=-\hat{i}$ $\vec{P}=P_x\hat{i}+P_y\hat{j}+P_z\hat{k}$ $\vec{Q}=Q_x\hat{i}+Q_y\hat{j}+Q_z\hat{k}$ $\vec{V}=\vec{P}\times\vec{Q}=\begin{vmatrix}\hat{i} & \hat{j} & \hat{k}\\ P_x & P_y & P_z\\ Q_x & Q_y & Q_z\end{vmatrix}=V_x\hat{i}+V_y\hat{j}+V_z\hat{k}$ $V_x=P_yQ_z-P_zQ_y$ $V_y=-(P_xQ_z-P_zQ_x)=P_zQ_x-P_xQ_z$ $V_z=P_xQ_y-P_yQ_x$	[trigonometric functions] (MA2G2) → 10th (2F) [cross product] → To be taught as a special math topic [dot product] → To be taught as a special math topic	[force] (S4P3) → 4th (3A) or (S8P3) → 8th (3C)	9th	

Statics Topics List (Continued).

Engineering Subject: Statics				
Engineering Analytic Topics & Typical Formulas	**Math & Science Pre-requisite Topics & Completion Grade (Georgia Performance Standard Code)** **[Pre-requisite Math Skills/Science Principles] (GPS Code) → Grade (Table No.)**		**Possible Grade to Start the Topic**	
	Math	**Physics**	**Sec**	**Ch**
Chapter 3: Rigid Bodies - Equivalent Systems of Forces (Continued)				
3.6: Moment of a Force about a Point $\vec{M}_0 = \vec{r} \times \vec{F} \quad M_0 = rF\sin\theta = Fd$ $\vec{r} = \vec{v}_{position}^{O \to A} \quad \theta = \angle_{\vec{r} \to \vec{F}} \quad d \perp \vec{F}$ $\vec{M}_0 = \vec{r} \times \vec{F} = \begin{vmatrix} \hat{i} & \hat{j} & \hat{k} \\ x & y & z \\ F_x & F_y & F_z \end{vmatrix} = M_x\hat{i} + M_y\hat{j} + M_z\hat{k}$ $M_x = yF_z - zF_y \quad M_y = -(xF_z - zF_x) = zF_x - xF_z \quad M_z = xF_y - yF_x$	[four operations] (M1N3) → 1^{st} (1A) + (M2N3) → 2^{nd} (2A) [geometry: point, axis/line, 3D body] (M6G1) (M6G2) (M6M3) → 6^{th} (2B) [\cross product] → To be taught as a special math topic [dot product] → To be taught as a special math topic [linear algebra](MA2A6) (MA2A7) (MA2A8) (MA2A9) → 10^{th} (2G) → To be taught as a special math topic	[force] (S4P3) → 4^{th} (3A) or (S8P3) → 8^{th} (3C)	9^{th}	9^{th}
3.7: Varignon's Theorem $\vec{r} \times (\vec{F}_1 + \vec{F}_2 + ...) = \vec{r} \times \vec{F}_1 + \vec{r} \times \vec{F}_2 + ...$	[four operations] (M1N3) → 1^{st} (1A) + (M2N3) → 2^{nd} (2A) [cross product] → To be taught as a special math topic [dot product] → To be taught as a special math topic	[force] (S4P3) → 4^{th} (3A) or (S8P3) → 8^{th} (3C)	9^{th}	
3.8: Rectangular Components of the Moment of a Force $\vec{M}_B = \vec{r}_{A/B} \times \vec{F} = \begin{vmatrix} \hat{i} & \hat{j} & \hat{k} \\ x_{A/B} & y_{A/B} & z_{A/B} \\ F_x & F_y & F_z \end{vmatrix}$ $\vec{r}_{A/B} = x_{A/B}\hat{i} + y_{A/B}\hat{j} + z_{A/B}\hat{k}$ $x_{A/B} = x_A - x_B \quad y_{A/B} = y_A - y_B \quad z_{A/B} = z_A - z_B$	[four operations] (M1N3) → 1^{st} (1A) + (M2N3) → 2^{nd} (2A) [cross product] → To be taught as a special math topic	[force] (S4P3) → 4^{th} (3A) or (S8P3) → 8^{th} (3C)	9^{th}	

Statics Topics List (Continued).

Engineering Subject: Statics				
Engineering Analytic Topics & Typical Formulas	**Math & Science Pre-requisite Topics & Completion Grade (Georgia Performance Standard Code)** **[Pre-requisite Math Skills/Science Principles] (GPS Code) → Grade (Table No.)**		**Possible Grade to Start the Topic**	
	Math	**Physics**	**Sec**	**Ch**
Chapter 3: Rigid Bodies - Equivalent Systems of Forces (Continued)				
3.9: Scalar Product of Two Vectors $\vec{P}\bullet\vec{Q}=PQ\cos\theta=P_xQ_x+P_yQ_y+P_zQ_z \quad \theta=\angle_{\vec{P}\to\vec{Q}}$ $\vec{P}\bullet\vec{Q}=\vec{Q}\bullet\vec{P} \quad \vec{P}\bullet(\vec{Q}_1+\vec{Q}_2)=\vec{P}\bullet\vec{Q}_1+\vec{P}\bullet\vec{Q}_2$ $P_{OL}=\vec{P}\bullet\hat{\lambda}=P_x\cos\theta_x+P_y\cos\theta_y+P_z\cos\theta_z$ (More formulas on p. pp. 94-95)	[four operations] (M1N3) → 1st (1A) + (M2N3) → 2nd (2A) [dot product] → To be taught as a special math topic	[force] (S4P3) → 4th (3A) or (S8P3) → 8th (3C)	9th	9th
3.10: Mixed Triple Product of Three Vectors $\vec{S}\bullet(\vec{P}\times\vec{Q})=\begin{vmatrix} S_x & S_y & S_z \\ P_x & P_y & P_z \\ Q_x & Q_y & Q_z \end{vmatrix}$	[four operations] (M1N3) → 1st (1A) + (M2N3) → 2nd (2A) [cross product] → To be taught as a special math topic	[force] (S4P3) → 4th (3A) or (S8P3) → 8th (3C)	9th	
3.11: Moment of a Force about a Given Axis $M_{OL}=\hat{\lambda}\bullet\vec{M}_O=\hat{\lambda}\bullet(\vec{r}\times\vec{F})=\begin{vmatrix} \lambda_x & \lambda_y & \lambda_z \\ x & y & z \\ F_x & F_y & F_z \end{vmatrix}$ (More formulas on p. pp. 98)	[four operations] (M1N3) → 1st (1A) + (M2N3) → 2nd (2A) [dot product] → To be taught as a special math topic	[force] (S4P3) → 4th (3A) or (S8P3) → 8th (3C)	9th	
3.12: Moment of a Couple $\vec{M}=\vec{r}\times\vec{F} \quad M=rF\sin\theta=Fd$	[four operations] (M1N3) → 1st (1A) + (M2N3) → 2nd (2A) [trigonometric functions] (MA2G2) → 10th (2F) → To be taught as a special math topic [cross product] → To be taught as a special math topic	[force] (S4P3) → 4th (3A) or (S8P3) → 8th (3C) [motion] (SKP2) → K (3A) [lever] (S4P3) → 4th (3A)	9th	
3.13: Equivalent Couples $F_1d_1=F_2d_2$	[four operations] (M1N3) → 1st (1A) + (M2N3) → 2nd (2A) [geometry: point, axis/line, 3D body] (M6G1) (M6G2) (M6M3) → 6th (2B)	[force] (S4P3) → 4th (3A) or (S8P3) → 8th (3C) [motion] (SKP2) → K (3A) [lever] (S4P3) → 4th (3A)	6th	

Statics Topics List (Continued).

Engineering Subject: Statics				
Engineering Analytic Topics & Typical Formulas	**Math & Science Pre-requisite Topics & Completion Grade (Georgia Performance Standard Code)** **[Pre-requisite Math Skills/Science Principles] (GPS Code) → Grade (Table No.)**		**Possible Grade to Start the Topic**	
	Math	**Physics**	**Sec**	**Ch**
Chapter 3: Rigid Bodies - Equivalent Systems of Forces (Continued)				
3.14: Addition of Couples $\vec{M} = \vec{r}\times\vec{R} = \vec{r}\times(\vec{F}_1+\vec{F}_2) = \vec{r}\times\vec{F}_1+\vec{r}\times\vec{F}_2 \quad \vec{M} = \vec{M}_1+\vec{M}_2$	[four operations] (M1N3) → 1st (1A) + (M2N3) → 2nd (2A) [cross product] → To be taught as a special math topic	[force] (S4P3) → 4th (3A) or (S8P3) → 8th (3C)	9th	9th
3.15: Couples Can Be Represented by Vectors	[vector graphics] (MA3A10) → 11th (2H) → To be taught as a special math topic	[force] (S4P3) → 4th (3A) or (S8P3) → 8th (3C)	9th	
3.16: Resolution of a Given Force Into a Force at *O* and a Couple $\vec{M}_{O'} = \vec{r}'\times\vec{F} = (\vec{r}+\vec{s})\times\vec{F} = \vec{r}\times\vec{F}+\vec{s}\times\vec{F} \quad \vec{M}_{O'} = \vec{M}_O+\vec{s}\times\vec{F}$	[four operations] (M1N3) → 1st (1A) + (M2N3) → 2nd (2A) [cross product] → To be taught as a special math topic	[force] (S4P3) → 4th (3A) or (S8P3) → 8th (3C)	9th	
3.17: Reduction of a System of Forces to One Force and One Couple $\vec{R} = \sum\vec{F} \quad \vec{M}_O^R = \sum\vec{M}_O = \sum(\vec{r}\times\vec{F})$ $\vec{M}_{O'}^R = \vec{M}_O+\vec{s}\times\vec{R} \quad \vec{r} = x\hat{i}+y\hat{j}+z\hat{k}$ $\vec{F} = F_x\hat{i}+F_y\hat{j}+F_z\hat{k} \quad \vec{R} = R_x\hat{i}+R_y\hat{j}+R_z\hat{k}$ $\vec{M}_O^R = M_x^R\hat{i}+M_y^R\hat{j}+M_z^R\hat{k}$	[four operations] (M1N3) → 1st (1A) + (M2N3) → 2nd (2A) [cross product] → To be taught as a special math topic	[force] (S4P3) → 4th (3A) or (S8P3) → 8th (3C)	9th	
3.18: Equivalent Systems of Forces $\sum\vec{F} = \sum\vec{F}'$ & $\sum\vec{M}_0 = \sum\vec{M}'_0$ $\sum\vec{F} = \sum\vec{F}'$ *and* $\sum\vec{M}_O = \vec{M}_O'$ $\sum F_x = \sum F'_x \quad \sum F_y = \sum F'_y \quad \sum F_z = \sum F'_z$ $\sum M_x = \sum M'_x \quad \sum M_y = \sum M'_y \quad \sum M_z = \sum M'_z$	[four operations] (M1N3) → 1st (1A) + (M2N3) → 2nd (2A) [coordinate system] (M4G3) → 4th (2B)	[force] (S4P3) → 4th (3A) or (S8P3) → 8th (3C)	8th	
3.19: Equipollent Systems of Vectors	[vector graphics] (MA3A10) → 11th (2H) → To be taught as a special math topic	[force] (S4P3) → 4th (3A) or (S8P3) → 8th (3C)	9th	
3.20: Further Reduction of a System of Forces	[coordinate system] (M4G3) → 4th (2B)	[force] (S4P3) → 4th (3A) or (S8P3) → 8th (3C)	8th	

Statics Topics List (Continued).

Engineering Subject: Statics				
Engineering Analytic Topics & Typical Formulas	**Math & Science Pre-requisite Topics & Completion Grade (Georgia Performance Standard Code)** **[Pre-requisite Math Skills/Science Principles] (GPS Code) → Grade (Table No.)**		**Possible Grade to Start the Topic**	
	Math	**Physics**	**Sec**	**Ch**
Chapter 3: Rigid Bodies - Equivalent Systems of Forces (Continued)				
3.21: Reduction of a System of Forces to a Wrench $p = \frac{M_1}{R}$ $M_1 = \frac{\vec{R} \bullet \vec{M}_O^R}{R}$ $p = \frac{M_1}{R} = \frac{\vec{R} \bullet \vec{M}_O^R}{R^2}$ $\vec{M}_1 = p\vec{R} \rightarrow \begin{matrix} \vec{M}_1 + \vec{r} \times \vec{R} = \vec{M}_O^R \\ p\vec{R} + \vec{r} \times \vec{R} = \vec{M}_O^R \end{matrix}$	[four operations] (M1N3) → 1st (1A) + (M2N3) → 2nd (2A) [geometry: point, axis/line, 3D body] (M6G1) (M6G2) (M6M3) → 6th (2B) [trigonometric functions] (MA2G2) → 10th (2F) → To be taught as a special math topic [dot product] → To be taught as a special math topic [cross product] → To be taught as a special math topic	[force] (S4P3) → 4th (3A) or (S8P3) → 8th (3C) [motion] (SKP2) → K (2A) [lever] (S4P3) → 4th (2A)	9th	9th
Chapter 4: Equilibrium of Rigid Bodies				
4.1: Introduction $\sum \vec{F} = 0$ $\sum F_x = 0$ $\sum F_y = 0$ $\sum F_z = 0$ $\sum \vec{M}_O = \sum(\vec{r} \times \vec{F}) = 0$ $\sum M_x = 0$ $\sum M_y = 0$ $\sum M_z = 0$	[sigma notation] (M6N1) → 6th (1A) or (MA1A3) → 9th (2E) → To be taught as a special math topic [coordinate system] (M4G3) → 4th (2B)	[force] (S4P3) → 4th (3A) or (S8P3) → 8th (3C) [Newton's 3rd Law: Action and Reaction] (SP1) → 9th (3C)	9th	9th
4.2: Free-Body Diagram				
<u>Equilibrium in Two Dimensions</u> **4.3: Reactions at Supports and Connections for a Two-Dimensional Structure**				
4.4: Equilibrium of a Rigid Body in Two Dimensions $F_z = 0$ $M_x = M_y = 0$ $M_z = M_O$ $\sum F_x = 0$ $\sum F_y = 0$ $\sum M_O = 0$ $\sum M_A = 0$ $\sum M_B = 0$ $\sum M_C = 0$				
4.5: Statically Indeterminate Reactions. Partial Constraints				
4.6: Equilibrium of a Two-Force Body				
4.7: Equilibrium of a Three-Force Body				

Statics Topics List (Continued).

Engineering Subject: Statics				
Engineering Analytic Topics & Typical Formulas	**Math & Science Pre-requisite Topics & Completion Grade (Georgia Performance Standard Code)** **[Pre-requisite Math Skills/Science Principles] (GPS Code) → Grade (Table No.)**		**Possible Grade to Start the Topic**	
	Math	**Physics**	**Sec**	**Ch**
Chapter 4: Equilibrium of Rigid Bodies (Continued)				
Equilibrium in Three Dimensions **4.8: Equilibrium of a Rigid Body in Three Dimensions** $\sum \vec{F} = 0 \quad \sum \vec{M}_O = \sum(\vec{r} \times \vec{F}) = 0$ $\sum F_x = 0 \quad \sum F_y = 0 \quad \sum F_z = 0$ $\sum M_x = 0 \quad \sum M_y = 0 \quad \sum M_z = 0$ **4.9: Reactions at Supports and Connections for a Three-Dimensional Structure**	[sigma notation] (M6N1) → 6th (1A) or (MA1A3) → 9th (2E) → To be taught as a special math topic [coordinate system] (M4G3) → 4th (2B)	[force] (S4P3) → 4th (3A) or (S8P3) → 8th (3C) [Newton's 3rd Law: Action and Reaction] (SP1) → 9th (3C)	9th	9th
Chapter 5: Distributed Forces: Centroids and Centers of Gravity				
5.1: Introduction **Areas and Lines** **5.2: Center of Gravity of a Two-Dimensional Body** $Plate: \ \sum F_z: \ W = \Delta W_1 + \Delta W_2 + ... + \Delta W_n$ $\sum M_y: \ \bar{x}W = x_1 \Delta W + x_2 \Delta W + ... + x_n \Delta W$ $\sum M_x: \ \bar{y}W = y_1 \Delta W + y_2 \Delta W + ... + y_n \Delta W$ $W = \int dW \quad \bar{x}W = \int x dW \quad \bar{y}W = \int y dW$ $Wire: \ \sum M_y: \ \bar{x}W = \sum x \Delta W \quad \sum M_x: \ \bar{y}W = \sum y \Delta W$	[coordinate system] (M4G3) → 4th (2B) [sigma notation] (M6N1) → 6th (1A) or (MA1A3) → 9th (2E) → To be taught as a special math topic [integration] → 12th (To be taught)	[force] (S4P3) → 4th (3A) or (S8P3) → 8th (3C) [Newton's Law of Gravitation] (S8P5) → 8th (3C)	PS	PS
5.3: Centroids of Areas and Lines $Plate: \ \Delta W = \gamma t \Delta A \quad W = \gamma t A \quad \bar{x}A = \int x dA \quad \bar{y}A = \int y dA$ $Line: \ \Delta W = \gamma a \Delta L \quad \bar{x}L = \int x dL \quad \bar{y}L = \int y dL$	[measurement: area, weight, thickness] (M6M1) (M6M2) → 6th (2C) [integration] → 12th (To be taught)	[force] (S4P3) → 4th (3A) or (S8P3) → 8th (3C) [Newton's Law of Gravitation] (S8P5) → 8th (3C)	PS	

Statics Topics List (Continued).

Engineering Subject: Statics				
Engineering Analytic Topics & Typical Formulas	**Math & Science Pre-requisite Topics & Completion Grade (Georgia Performance Standard Code)** **[Pre-requisite Math Skills/Science Principles] (GPS Code) → Grade (Table No.)**		**Possible Grade to Start the Topic**	
	Math	**Physics**	**Sec**	**Ch**
Chapter 5: Distributed Forces: Centroids and Centers of Gravity (Continued)				
5.4: First Moments of Areas and Lines $\bar{x}A = Q_y = \int x dA \quad \bar{y}A = Q_x = \int y dA$	[integration] → 12^{th} (To be taught) [coordinate system] (M4G3) → 4^{th} (2B) [two-dimensional figures: circle, arc, triangle, ellipse, parabolic] (M1G1) (M1G2) → 1^{st} (1B) + (MA2G4) → 10^{th} (2F) → To be taught as a special math topic [special two-dimensional figures: parabolic spandrel, general spandrel] → To be taught as a special math topic	[force] (S4P3) → 4^{th} (3A) or (S8P3) → 8^{th} (3C) [Newton's Law of Gravitation] (S8P5) → 8^{th} (3C)	PS	PS
5.5: Composite Plates and Wires $\bar{X}\sum W = \sum \bar{x}W \quad \bar{Y}\sum W = \sum \bar{y}W$ $Q_y = \bar{X}\sum A = \sum \bar{x}A \quad Q_x = \bar{Y}\sum A = \sum \bar{y}A$	[coordinate system] (M4G3) → 4^{th} (2B) [sigma notation] (M6N1) → 6^{th} (1A) or (MA1A3) → 9^{th} (2E) → To be taught as a special math topic [measurement: area, weight, thickness] (M6M1) (M6M2) → 6^{th} (2C)	[force] (S4P3) → 4^{th} (3A) or (S8P3) → 8^{th} (3C) [Newton's Law of Gravitation] (S8P5) → 8^{th} (3C)	PS	
5.6: Determination of Centroids by Integration $Q_y = \bar{x}A = \int \bar{x}_{el} dA \quad Q_x = \bar{y}A = \int \bar{y}_{el} dA$	[integration] → 12^{th} (To be taught) [coordinate system] (M4G3) → 4^{th} (2B) [areas of geometric shapes: circle, triangle, etc.] (M5M1) → 5^{th} and (2B) (M6M2) → 6^{th} (2C)	[force] (S4P3) → 4^{th} (3A) or (S8P3) → 8^{th} (3C) [Newton's Law of Gravitation] (S8P5) → 8^{th} (3C)	PS	
5.7: Theorems of Pappus-Guldinus $A = 2\pi \bar{y} L \quad V = 2\pi \bar{y} A$	[integration: area of surface of revolution, curve, volume of body of revolution] → 12^{th} (To be taught)	[force] (S4P3) → 4^{th} (3A) or (S8P3) → 8^{th} (3C) [Newton's Law of Gravitation] (S8P5) → 8^{th} (3C)	PS	
5.8: Distributed Loads on Beams $W = \int_O^L w dx \quad W = \int dA = A \quad (OP)W = \int x dW \quad (OP)A = \int_O^L x dA$	[coordinate system] (M4G3) → 4^{th} (2B) [integration] → 12^{th} (To be taught) [areas of geometric shapes: circle, triangle, etc.] (M5M1) → 5^{th} and (2B) (M6M2) → 6^{th} (2C)	[force] (S4P3) → 4^{th} (3A) or (S8P3) → 8^{th} (3C) [Newton's Law of Gravitation] (S8P5) → 8^{th} (3C)	PS	
5.9: Forces on Submerged Surfaces $w = bp = b\gamma h$	[areas of geometric shapes: circle, triangle, etc.] (M5M1) → 5^{th} and (2B) (M6M2) → 6^{th} (2C)	[force] (S4P3) → 4^{th} (3A) or (S8P3) → 8^{th} (3C)	8^{th} → PS	

Statics Topics List (Continued).

Engineering Subject: Statics				
Engineering Analytic Topics & Typical Formulas	**Math & Science Pre-requisite Topics & Completion Grade (Georgia Performance Standard Code)** **[Pre-requisite Math Skills/Science Principles] (GPS Code) → Grade (Table No.)**		**Possible Grade to Start the Topic**	
	Math	**Physics**	**Sec**	**Ch**
Chapter 5: Distributed Forces: Centroids and Centers of Gravity (Continued)				
Volumes **5.10: Center of Gravity of a Three- Dimensional Body. Centroid of a Volume** $\bar{x}W = \int x\,dW \quad \bar{y}W = \int y\,dW \quad \bar{z}W = \int z\,dW$ $\bar{x}V = \int x\,dV \quad \bar{y}V = \int y\,dV \quad \bar{z}V = \int z\,dV$	[coordinate system] (M4G3) → 4^{th} (2B) [volume: sphere, cone, pyramid] (M5M4) → 5^{th} (1B) (M6M3) → 6^{th} (2B) (MA1G5) → 9^{th} (2F) [volume: ellipsoid, paraboloid] → To be taught as a special math topic [integration] → 12^{th} (To be taught) [integration: area of surface of revolution, curve, volume of body of revolution] → 12^{th} (To be taught)	[force] (S4P3) → 4^{th} (3A) or (S8P3) → 8^{th} (3C) [Newton's Law of Gravitation] (S8P5) → 8^{th} (3C)	PS	PS
5.11: Composite Bodies $\bar{X}\sum W = \sum \bar{x}W \quad \bar{Y}\sum W = \sum \bar{y}W \quad \bar{Z}\sum W = \sum \bar{z}W$ $\bar{X}\sum V = \sum \bar{x}V \quad \bar{Y}\sum V = \sum \bar{y}V \quad \bar{Z}\sum V = \sum \bar{z}V$				
5.12: Determination of Centroids of Volumes by Integration $\bar{x}V = \int \bar{x}_{el}\,dV \quad \bar{y}V = \int \bar{y}_{el}\,dV \quad \bar{z}V = \int \bar{z}_{el}\,dV \quad \bar{x}V = \int \bar{x}_{el}\,dV$				
Chapter 6: Analysis of Structures				
6.1: Introduction	[sigma notation] (M6N1) → 6^{th} (1A) or (MA1A3) → 9^{th} (2E) → To be taught as a special math topic [four operations] (M1N3) → 1^{st} (1A) + (M2N3) → 2^{nd} (1A), or (M7N1) → 7^{th} (2A) [coordinate system] (M4G3) → 4^{th} (2B)	[force] (S4P3) → 4^{th} (3A) or (S8P3) → 8^{th} (3C) [Newton's 3^{rd} Law: Action and Reaction] (SP1) → 9^{th} (3C)	9^{th}	9^{th}
Trusses **6.2: Definition of a Truss**				
6.3: Simple Trusses				
6.4: Analysis of Trusses by the Method of Joints				
6.5: Joints under Special Loading Conditions				
6.6: Space Trusses				
6.7: Analysis of Trusses by the Method of Sections				
6.8: Trusses Made of Several Simple Trusses				
Frames and Machines **6.9: Structures Containing Multiforce Members**	[trigonometric functions] (MA2G2) → 10^{th} (2F) [coordinate system] (M4G3) → 4^{th} (2B) [sigma notation] (M6N1) → 6^{th} (1A) or (MA1A3) → 9^{th} (2E) → To be taught as a special math topic [four operations] (M1N3) → 1^{st} (2A) + (M2N3) → 2^{nd} (1A), or (M7N1) → 7^{th} (2A)	[force] (S4P3) → 4^{th} (3A) or (S8P3) → 8^{th} (3C) [Newton's 3^{rd} Law: Action and Reaction] (SP1) → 9^{th} (3C)	9^{th}	
6.10: Analysis of a Frame				
6.11: Frames Which Cease to Be Rigid When Detached from Their Supports				

Statics Topics List (Continued).

Engineering Subject: Statics				
Engineering Analytic Topics & Typical Formulas	**Math & Science Pre-requisite Topics & Completion Grade (Georgia Performance Standard Code)** **[Pre-requisite Math Skills/Science Principles] (GPS Code) → Grade (Table No.)**		**Possible Grade to Start the Topic**	
	Math	**Physics**	**Sec**	**Ch**
Chapter 6: Analysis of Structures (Continued)				
6.12: Machines	[sigma notation] (M6N1) → 6^{th} (1A) or (MA1A3) → 9^{th} (2E) → To be taught as a special math topic [four operations] (M1N3) → 1^{st} (2A) + (M2N3) → 2^{nd} (1A), or (M7N1) → 7^{th} (2A) [trigonometric functions] (MA2G2) → 10^{th} (2F) → To be taught as a special math topic [coordinate system] (M4G3) → 4^{th} (2B)	[force] (S4P3) → 4^{th} (3A) or (S8P3) → 8^{th} (3C) [Newton's 3^{rd} Law: Action and Reaction] (SP1) → 9^{th} (3C)	9^{th}	9^{th}
Chapter 7: Forces in Beams and Cables				
7.1: Introduction **7.2: Internal Forces in Members** **Beams** **7.3: Various Types of Loading and Support** **7.4: Shear and Bending Moment in a Beam** **7.5: Shear and Bending-Moment Diagrams**	[sigma notation] (M6N1) → 6^{th} (1A) or (MA1A3) → 9^{th} (2E) → To be taught as a special math topic [four operations] (M1N3) → 1^{st} (2A) + (M2N3) → 2^{nd} (2A), or (M7N1) → 7^{th} (2A) [integration] → 12^{th} (To be taught)	[force] (S4P3) → 4^{th} (3A) or (S8P3) → 8^{th} (3C)	PS	PS
7.6: Relations among Load, Shear, and Bending Moment $\frac{dV}{dx} = -w$ $V_D - V_C = -\int_{x_C}^{x_D} w\,dx = -wx = =$ -(Area under load curve between C an D) $\frac{dM}{dx} = V$ $M_D - M_C = \int_{x_C}^{x_D} V\,dx = -$(Area under shear curve between C an D)	[sigma notation] (M6N1) → 6^{th} (1A) or (MA1A3) → 9^{th} (2E) → To be taught as a special math topic [four operations] (M1N3) → 1^{st} (1A) + (M2N3) → 2^{nd} (1A), or (M7N1) → 7^{th} (2A) [integration] → 12^{th} (to be taught) [differentiation] → 12^{th} (to be taught)	[force] (S4P3) → 4^{th} (3A) or (S8P3) → 8^{th} (3C)	PS	

Statics Topics List (Continued).

Engineering Subject: Statics				
Engineering Analytic Topics & Typical Formulas	**Math & Science Pre-requisite Topics & Completion Grade (Georgia Performance Standard Code)** **[Pre-requisite Math Skills/Science Principles] (GPS Code) → Grade (Table No.)**		**Possible Grade to Start the Topic**	
	Math	**Physics**	**Sec**	**Ch**
Chapter 7: Forces in Beams and Cables (Continued)				
Cables **7.7: Cables with Concentrated Loads** **7.8: Cables with Distributed Loads** $T\cos\theta = T_O \quad T\sin\theta = W \quad T = \sqrt{T_O^2 + W^2} \quad \tan\theta = \frac{W}{T_O}$ **7.9: Parabolic Cable** $y = \frac{wx^2}{2T_O}$	[sigma notation] (M6N1) → 6^{th} (1A) or (MA1A3) → 9^{th} (2E) → To be taught as a special math topic [trigonometric functions] (MA2G2) → 10^{th} (2F) → To be taught as a special math topic [four operations] (M1N3) → 1^{st} (2A) + (M2N3) → 2^{nd} (2A), or (M7N1) → 7^{th} (2A) [square root] (M8N1) → 8^{th} (2A)	[force] (S4P3) → 4^{th} (3A) or (S8P3) → 8^{th} (3C)	8^{th}	PS
7.10: Catenary $T = \sqrt{T_O^2 + w^2s^2} \quad c = \frac{T_O}{w} \quad T_O = wc \quad W = ws \quad T = w\sqrt{c^2 + s^2}$ $dx = ds\cos\theta = \frac{T_O}{T}ds = \frac{wcds}{w\sqrt{c^2+s^2}}$ $x = \int_O^S \frac{ds}{\sqrt{1+\frac{s^2}{c^2}}} = c\left[\sinh^{-1}\frac{s}{c}\right]_O^S = c\sinh^{-1}\frac{s}{c}$ $s = c\sinh\frac{x}{c} \quad y = c\cosh\frac{x}{c} \quad y^2 - s^2 = c^2 \quad T_O = wc \quad W = ws$ $T = wy \quad h = y_A = c$	[sigma notation] (M6N1) → 6^{th} (1A) or (MA1A3) → 9^{th} (2E) → To be taught as a special math topic [trigonometric functions] (MA2G2) → 9^{th} (2F) [four operations] (M1N3) → 1^{st} (2A) + (M2N3) → 2^{nd} (2A), or (M7N1) → 7^{th} (2A) [square root] (M8N1) → 8^{th} (2A) [integration] → 12^{th} (to be taught) [differentiation] → 12^{th} (to be taught)	[force] (S4P3) → 4^{th} (3A) or (S8P3) → 8^{th} (3C)	PS	

Statics Topics List (Continued).

Engineering Subject: Statics				
Engineering Analytic Topics & Typical Formulas	**Math & Science Pre-requisite Topics & Completion Grade (Georgia Performance Standard Code)** **[Pre-requisite Math Skills/Science Principles] (GPS Code) → Grade (Table No.)**		**Possible Grade to Start the Topic**	
	Math	**Physics**	**Sec**	**Ch**
Chapter 8: Friction				
8.1: Introduction **8.2: The Laws of Dry Friction. Coefficients of Friction** $F_m = \mu_s N \quad F_k = \mu_k N$ **8.3: Angles of Friction** $\tan\phi_s = \frac{F_m}{N} = \frac{\mu_s N}{N} \rightarrow \tan\phi_s = \mu_s$ $\tan\phi_k = \frac{F_k}{N} = \frac{\mu_k N}{N} \rightarrow \tan\phi_k = \mu_k$ **8.4: Problems Involving Dry Friction** **8.5: Wedges** **8.6: Square-Threaded Screws** $Q = P\frac{a}{r} \quad L = nP$ **8.7: Journal Bearings. Axle Friction** $M = Rr\sin\phi_k \approx Rr\mu_k \quad r_f = r\sin\phi_k \approx r\mu_k$	[four operations] (M1N3) → 1st (2A) + (M2N3) → 2nd (2A), or (M7N1) → 7th (2A) [trigonometric functions] (MA2G2) → 10th (2F) → To be taught as a special math topic [surface] (M6M4) → 6th (2B)	[force] (S4P3) → 4th (3A) or (S8P3) → 8th (3C)	9th	PS
8.8: Thrust Bearings. Disk Friction $\Delta M = r\Delta F = \frac{r\mu_k P\Delta A}{\pi(R_2^2 - R_1^2)}$ $M = \frac{\mu_k P}{\pi(R_2^2 - R_1^2)}\int_0^{2\pi}\int_{R_1}^{R_2} r^2 dr d\theta = \frac{\mu_k P}{\pi(R_2^2 - R_1^2)}\int_0^{2\pi}\left[\frac{r^{2+1}}{2+1}\right]_{R_1}^{R_2} d\theta$ $= \frac{\mu_k P}{\pi(R_2^2 - R_1^2)}\int_0^{2\pi}\frac{1}{3}(R_2^3 - R_1^3)d\theta$ Ring area : $M = \frac{2}{3}\mu_k P\frac{R_2^3 - R_1^3}{R_2^2 - R_1^2}$ Full circle : $M = \frac{2}{3}\mu_k PR$	[four operations] (M1N3) → 1st (2A) + (M2N3) → 2nd (2A), or (M7N1) → 7th (2A) [integration] → 12th (to be taught)	[force] (S4P3) → 4th (3A) or (S8P3) → 8th (3C)	PS	
8.9: Wheel Friction. Rolling Resistance $\Pr = Wb$	[four operations] (M1N3) → 1st (2A) + (M2N3) → 2nd (2A), or (M7N1) → 7th (2A)	[force] (S4P3) → 4th (3A) or (S8P3) → 8th (3C)	8th	

Statics Topics List (Continued).

Engineering Subject: Statics				
Engineering Analytic Topics & Typical Formulas	Math & Science Pre-requisite Topics & Completion Grade (Georgia Performance Standard Code) [Pre-requisite Math Skills/Science Principles] (GPS Code) → Grade (Table No.)		Possible Grade to Start the Topic	
	Math	Physics	Sec	Ch
Chapter 8: Friction (Continued)				
8.10: Belt Friction $\ln\frac{T_2}{T_1}=\mu_s\beta \quad \frac{T_2}{T_1}=e^{\mu_s\beta}$ (For other formulas, refer to pp. 451-452)	[sigma notation] (M6N1) → 6th (1A) or (MA1A3) → 9th (2E) → To be taught as a special math topic [four operations] (M1N3) → 1st (2A) + (M2N3) → 2nd (2A), or (M7N1) → 7th (2A) [trigonometric functions] (MA2G2) → 10th (2F) → To be taught as a special math topic [logarithmic functions] (MA2A4) → 10th (2E) → To be taught as a special math topic [integration] → 12th (to be taught) [differentiation] → 12th (to be taught)	[force] (S4P3) → 4th (3A) or (S8P3) → 8th (3C)	PS	PS

Statics Topics List (Continued).

Engineering Subject: Statics				
Engineering Analytic Topics & Typical Formulas	**Math & Science Pre-requisite Topics & Completion Grade (Georgia Performance Standard Code)** **[Pre-requisite Math Skills/Science Principles] (GPS Code) → Grade (Table No.)**		**Possible Grade to Start the Topic**	
	Math	**Physics**	**Sec**	**Ch**
Chapter 9: Distributed Forces: Moments of Inertia				
9.1: Introduction **<u>Moments of Inertia of Areas</u>** **9.2: Second Moment, or Moment of Inertia, of an Area** $R=\int kydA=k\int ydA \quad M=\int ky^2dA=k\int y^2dA$ $R=\int \gamma ydA=\gamma\int ydA \quad M_x=\int y^2dA=\gamma\int y^2dA$ **9.3: Determination of the Moment of Inertia of an Area by Integration** $I_x=\int y^2dA \quad I_y=\int x^2dA \quad dA=b\,dy \quad dI_x=y^2b\,dy$ $I_x=\int_O^h by^2dy=\frac{1}{3}BH^3 \quad dI_x=\frac{1}{3}y^3dx \quad dI_y=x^2dA=x^2ydx$ **9.4: Polar Moment of Inertia** $J_O=\int r^2\,dA=\int(x^2+y^2)dA=\int y^2dA+\int x^2dA$ $J_O==I_x+I_y$ **9.5: Radius of Gyration of an Area** $I_x=k_x^2A \rightarrow k_x=\sqrt{\frac{I_x}{A}} \quad I_y=k_y^2A \rightarrow k_y=\sqrt{\frac{I_y}{A}}$ $J_O=k_O^2A \rightarrow k_O=\sqrt{\frac{J_O}{A}}$ **9.6: Parallel-Axis Theorem** $I=\int y^2dA$ $I=\int y^2dA=\int(y'+d)^2dA=\int y'^2\,dA+2d\int y'dA+d^2\int dA$ $I=\bar{I}+Ad^2 \quad k^2=\bar{k}^2+d^2 \quad J_O=\bar{J}_O+Ad^2 \quad or \quad k_O^2=\bar{k}_O^2+d^2$	[integration] → 12th (to be taught) [differentiation] → 12th (to be taught) [four operations] (M1N3) → 1st (2A) + (M2N3) → 2nd (2A), or (M7N1) → 7th (2A) [area] (M3M3) (M3M4) → 3rd (2B) [square root] (M8N1) → 8th (2A) [coordinate system] (M4G3) → 4th (2B) [areas of geometric shapes: circle, triangle] (M5M1) → 5th (2B) [geometric shapes: ellipse] (MA2G4) → 10th (2F) → To be taught as a special math topic [three-dimensional bodies: thin rectangular plate, rectangular prism] (M5M4) → 5th (2B) [three-dimensional bodies: slender rod, circular cylinder, cone] (M6M3) → 6th (2B) [three-dimensional bodies: circular cone, sphere] (M2G2) → 2nd (2B) [trigonometric functions] (MA2G2) → 10th (2F) → To be taught as a special math topic [cross product] → To be taught as a special math topic [partial differentiation] → 12th (to be taught) [gradient: “del”] → 12th (to be taught) [linear algebra] (MA2A6) (MA2A7) (MA2A8) (MA2A9) → 10th (2G)	[force] (S4P3) → 4th (3A) or (S8P3) → 8th (3C) [power] (SP3) → 9th (3C)	PS	PS

Statics Topics List (Continued).

Engineering Subject: Statics				
Engineering Analytic Topics & Typical Formulas	**Math & Science Pre-requisite Topics & Completion Grade (Georgia Performance Standard Code)** **[Pre-requisite Math Skills/Science Principles] (GPS Code) → Grade (Table No.)**		**Possible Grade to Start the Topic**	
	Math	**Physics**	**Sec**	**Ch**
Chapter 9: Distributed Forces: Moments of Inertia (Continued)				
9.7: Moments of Inertia of Composite Areas (Formulas for moments of inertia of common geometric shapes can be found on page 485) **9.8: Product of Inertia** $I_{xy} = \int xy \; dA = \int (x'+\bar{x})(y'+\bar{y}) dA$ $= \int x' y' dA + \bar{y}\int x' dA + \bar{x}\int y' dA + \bar{x}\bar{y}\int dA$ $I_{xy} == \bar{I}_{x'y'} + \bar{x}\bar{y}A$ **9.9: Principal Axes and Principal Moments of Inertia** (Formulas for principle axis and principle moments of inertia can be found on pages 498-500) **9.10: Mohr's Circle for Moments and Products of Inertia** **<u>Moments of Inertia of Masses</u>** **9.11: Moment of Inertia of a Mass** $I = \int r^2 dm \quad I = k^2 m \quad or \quad k = \sqrt{\frac{I}{m}}$ $I_x = \int (y^2 + z^2) dm \quad I_y = \int (z^2 + x^2) dm$ $I_z = \int (x^2 + y^2) dm$ Note: This Chapter involves substantial amount of calculus-based computations; and is most likely beyond high school students' mathematics skill level.	[integration] → 12th (to be taught) [differentiation] → 12th (to be taught) [four operations] (M1N3) → 1st (2A) + (M2N3) → 2nd (2A), or (M7N1) → 7th (2A) [area] (M3M3) (M3M4) → 3rd (2B) [square root] (M8N1) → 8th (2A) [coordinate system] (M4G3) → 4th (2B) [areas of geometric shapes: circle, triangle] (M5M1) → 5th (2B) [geometric shapes: ellipse] (MA2G4) → 10th (2F) → To be taught as a special math topic [three-dimensional bodies: thin rectangular plate, rectangular prism] (M5M4) → 5th (2B) [three-dimensional bodies: slender rod, circular cylinder, cone] (M6M3) → 6th (2B) [three-dimensional bodies: circular cone, sphere] (M2G2) → 2nd (2B) [trigonometric functions] (MA2G2) → 10th (2F) → To be taught as a special math topic [cross product] → To be taught as a special math topic [partial differentiation] → 12th (to be taught) [gradient: "del"] → 12th (to be taught) [linear algebra] (MA2A6) (MA2A7) (MA2A8) (MA2A9) → 10th (2G) → To be taught as a special math topic	[force] (S4P3) → 4th (3A) or (S8P3) → 8th (3C) [power] (SP3) → 9th (3C)	PS	PS

Statics Topics List (Continued).

Engineering Subject: Statics				
Engineering Analytic Topics & Typical Formulas	**Math & Science Pre-requisite Topics & Completion Grade (Georgia Performance Standard Code)** **[Pre-requisite Math Skills/Science Principles] (GPS Code) → Grade (Table No.)**		**Possible Grade to Start the Topic**	
	Math	**Physics**	**Sec**	**Ch**
Chapter 9: Distributed Forces: Moments of Inertia (Continued)				
9.12: Parallel-Axis Theorem $x = x'+\bar{x} \quad y = y'+\bar{y} \quad z = z'+\bar{z}$ $I_x = \int (y^2+z^2)dm$ $I_x = \bar{I}_{x'} + m(\bar{y}^2+\bar{z}^2) = \int[(y'+\bar{y})^2+(z'+\bar{z})^2]dm$ $= \int (y'^2+z'^2)dm + 2\bar{y}\int y'\,dm + 2\bar{z}\int z'\,dm + (\bar{y}^2+\bar{z}^2)\int dm$ $I_y = \bar{I}_{y'} + m(\bar{z}^2+\bar{x}^2) \quad I_z = \bar{I}_{z'}+m(\bar{x}^2+\bar{y}^2)$ $I = \bar{I}+md^2 \quad k^2=\bar{k}^2+d^2$	[integration] → 12th (to be taught) [differentiation] → 12th (to be taught) [four operations] (M1N3) → 1st (2A) + (M2N3) → 2nd (2A), or (M7N1) → 7th (2A) [area] (M3M3) (M3M4) → 3rd (2B) [square root] (M8N1) → 8th (2A) [coordinate system] (M4G3) → 4th (2B) [areas of geometric shapes: circle, triangle] (M5M1) → 5th (2B) [geometric shapes: ellipse] (MA2G4) → 10th (2F) → To be taught as a special math topic [three-dimensional bodies: thin rectangular plate, rectangular prism] (M5M4) → 5th (2B) [three-dimensional bodies: slender rod, circular cylinder, cone] (M6M3) → 6th (2B) [three-dimensional bodies: circular cone, sphere] (M2G2) → 2nd (2B) [trigonometric functions] (MA2G2) → 10th (2F) → To be taught as a special math topic [cross product] → To be taught as a special math topic [partial differentiation] → 12th (to be taught) [gradient: "del"] → 12th (to be taught) [linear algebra] (MA2A6) (MA2A7) (MA2A8) (MA2A9) → 10th (2G) → To be taught as a special math topic	[force] (S4P3) → 4th (3A) or (S8P3) → 8th (3C) [power] (SP3) → 9th (3C)	PS	PS
9.13: Moments of Inertia of Thin Plates $\left.\begin{array}{l} I_{AA',mass}=\int r^2dm \\ dm=\rho t\,dA\end{array}\right\} \quad I_{AA',mass}=\rho t\int r^2 dA$ $I_{AA',mass}=\rho t I_{AA',area} \quad I_{BB',mass}=\rho t I_{BB',area}$ $I_{CC',mass}=\rho t J_{C,area} \quad I_{CC'}=I_{AA'}+I_{BB'}$ Rectangular Plate $I_{AA',mass}=\rho t I_{AA',area}=\rho t\left(\frac{1}{12}a^3b\right) \quad I_{BB',mass}=\rho t I_{BB',area}=\rho t\left(\frac{1}{12}ab^3\right)$ $I_{AA'}=\frac{1}{12}ma^2 \quad I_{BB'}=\frac{1}{12}mb^2 \quad I_{CC'}=I_{AA'}+I_{BB'}=\frac{1}{12}m(a^2+b^2)$ Circular Plate $I_{AA',mass}=\rho t I_{AA',area}=\rho t\left(\frac{1}{4}\pi r^4\right) \quad I_{AA'}=I_{BB'}=\frac{1}{4}mr^2$ $I_{CC'}=I_{AA'}+I_{BB'}=\frac{1}{12}mr^2$				

Statics Topics List (Continued).

Engineering Subject: Statics				
Engineering Analytic Topics & Typical Formulas	**Math & Science Pre-requisite Topics & Completion Grade (Georgia Performance Standard Code)** **[Pre-requisite Math Skills/Science Principles] (GPS Code) → Grade (Table No.)**		**Possible Grade to Start the Topic**	
	Math	**Physics**	**Sec**	**Ch**
Chapter 9: Distributed Forces: Moments of Inertia (Continued)				
9.14: Determination of the Moment of Inertia of a Three-Dimensional Body by Integration (Formulas for mass moments of inertia of common geometric shapes can be found on page 517). **9.15: Moments of Inertia of Composite Bodies** **9.16: Moment of Inertia of a Body with Respect to an Arbitrary Axis through *O*. Mass Products of Inertia** $I_{OL} = \int p^2 dm = \int \lvert \vec{\lambda} \times \vec{r} \rvert^2 dm$ $= \int [(\lambda_x y - \lambda_y x)^2 + (\lambda_y z - \lambda_z y)^2 + (\lambda_z x - \lambda_x z)^2]$ $= \lambda_x^2 \int (y^2 + z^2) dm + \lambda_y^2 \int (z^2 + x^2) dm + \lambda_z^2 \int (x^2 + y^2) dm -$ $2\lambda_x \lambda_y \int xy\ dm - 2\lambda_y \lambda_z \int yz\ dm - 2\lambda_z \lambda_x \int zx\ dm$ $I_{xy} = \int xy\ dm \quad I_{yz} = \int yz\ dm \quad I_{zx} = \int zx\ dm$ $I_{OL} = I_x \lambda_x^2 + I_y \lambda_y^2 + I_z \lambda_z^2 - 2I_{xy}\lambda_x \lambda_y - 2I_{yz}\lambda_y \lambda_{yz} - 2I_{zx}\lambda_z \lambda_x$ $I_{xy} = \bar{I}_{x'y'} + m\overline{xy} \quad I_{yz} = \bar{I}_{y'z'} + m\overline{yz} \quad I_{zx} = \bar{I}_{z'x'} + m\overline{zx}$ **9.17: Ellipsoid of Inertia. Principal Axes of Inertia** $(OQ)\lambda_x = x \quad (OQ)\lambda_y = y \quad (OQ)\lambda_z = z$ $I_x x^2 + I_y y^2 + I_z z^2 - 2I_{xy}xy - 2I_{yz}yz - 2I_{zx}zx = 1$ $I_{x'}x'^2 + I_{y'}y'^2 + I_{z'}z'^2 = 1$ $I_{OL} = I_{x'}\lambda_{x'}^2 + I_{y'}\lambda_{y'}^2 + I_{z'}\lambda_{z'}^2$	[integration] → 12th (to be taught) [differentiation] → 12th (to be taught) [four operations] (M1N3) → 1st (2A) + (M2N3) → 2nd (2A), or (M7N1) → 7th (2A) [area] (M3M3) (M3M4) → 3rd (2B) [square root] (M8N1) → 8th (2A) [coordinate system] (M4G3) → 4th (2B) [areas of geometric shapes: circle, triangle] (M5M1) → 5th (2B) [geometric shapes: ellipse] (MA2G4) → 10th (2F) → To be taught as a special math topic [three-dimensional bodies: thin rectangular plate, rectangular prism] (M5M4) → 5th (2B) [three-dimensional bodies: slender rod, circular cylinder, cone] (M6M3) → 6th (2B) [three-dimensional bodies: circular cone, sphere] (M2G2) → 2nd (1B) [trigonometric functions] (MA2G2) → 9th (2F) [cross product] → To be taught as a special math topic [partial differentiation] → 12th (to be taught) [gradient: "del"] → 12th (to be taught) [linear algebra] (MA2A6) (MA2A7) (MA2A8) (MA2A9) → 10th (2G) → To be taught as a special math topic	[force] (S4P3) → 4th (3A) or (S8P3) → 8th (3C) [power] (SP3) → 9th (3C)	PS	PS

Statics Topics List (Continued).

Engineering Subject: Statics				
Engineering Analytic Topics & Typical Formulas	**Math & Science Pre-requisite Topics & Completion Grade (Georgia Performance Standard Code)** **[Pre-requisite Math Skills/Science Principles] (GPS Code) → Grade (Table No.)**		**Possible Grade to Start the Topic**	
	Math	**Physics**	**Sec**	**Ch**
Chapter 9: Distributed Forces: Moments of Inertia (Continued)				
9.18: Determination of the Principal Axes and Principal Moments of Inertia of a Body of Arbitrary Shape $\left.\begin{aligned}\nabla f &= (2K)\vec{r}\\ K &= \text{constant}\\ \vec{r} &= x\hat{i}+y\hat{j}+z\hat{k}\end{aligned}\right\} \rightarrow \nabla f = \frac{\partial f}{\partial x}\hat{i}+\frac{\partial f}{\partial y}\hat{j}+\frac{\partial f}{\partial z}\hat{k}$ $f(x,y,z) = I_x x^2 + I_y y^2 + I_z z^2 - 2I_{xy}xy - 2I_{yz}yz - 2I_{zx}zx - 1$ … $\begin{vmatrix} I_x - K & -I_{xy} & -I_{zx} \\ -I_{xy} & I_y - K & -I_{yz} \\ -I_{zx} & -I_{yz} & I_z - K \end{vmatrix} = 0$ (More calculus- and linear algebra- based formulas can be found n pages 534-535)	[integration] → 12th (to be taught) [differentiation] → 12th (to be taught) [four operations] (M1N3) → 1st (2A) + (M2N3) → 2nd (2A), or (M7N1) → 7th (2A) [area] (M3M3) (M3M4) → 3rd (2B) [square root] (M8N1) → 8th (1A) [coordinate system] (M4G3) → 4th (2B) [areas of geometric shapes: circle, triangle] (M5M1) → 5th (2B) [geometric shapes: ellipse] (MA2G4) → 10th (2F) → To be taught as a special math topic [three-dimensional bodies: thin rectangular plate, rectangular prism] (M5M4) → 5th (2B) [three-dimensional bodies: slender rod, circular cylinder, cone] (M6M3) → 6th (2B) [three-dimensional bodies: circular cone, sphere] (M2G2) → 2nd (2B) [trigonometric functions] (MA2G2) → 10th (2F) → To be taught as a special math topic [cross product] → To be taught as a special math topic [partial differentiation] → 12th (to be taught) [gradient: “del”] → 12th to be taught) [linear algebra] (MA2A6) (MA2A7) (MA2A8) (MA2A9) → 10th (2G) → To be taught as a special math topic	[force] (S4P3) → 4th (3A) or (S8P3) → 8th (3C) [power] (SP3) → 9th (3C)	PS	PS

Statics Topics List (Continued).

Engineering Subject: Statics				
Engineering Analytic Topics & Typical Formulas	**Math & Science Pre-requisite Topics & Completion Grade (Georgia Performance Standard Code)** **[Pre-requisite Math Skills/Science Principles] (GPS Code) → Grade (Table No.)**		**Possible Grade to Start the Topic**	
	Math	**Physics**	**Sec**	**Ch**
Chapter 10: Method of Virtual Work				
10.1: Introduction	[integration] → 12th (to be taught) [differentiation] → 12th (to be taught) [trigonometric functions] (MA2G2) → 10th (2F) → To be taught as a special math topic [dot product] → To be taught as a special math topic [coordinate system] (M4G3) → 4th (2B) [partial differentiation] → 12th (to be taught)	[force] (S4P3) → 4th (3A) or (S8P3) → 8th (3C) [work] (S8P3) → 8th (3C) [potential energy] (SP3) → 9th (3C)	PS	PS
10.2: Work of a Force $dU = \vec{F} \bullet d\vec{x} \quad dU = F\,ds\cos\alpha \quad dU = M\ d\theta$				
10.3: Principle of Virtual Work $\delta U = \vec{F}_1 \bullet \delta\vec{r} + \vec{F}_2 \bullet \delta\vec{r} + ... + \vec{F}_n \bullet \delta\vec{r}$ $= \left(\vec{F}_1 + \vec{F}_2 + ... + \vec{F}_n\right) \bullet \delta\vec{r} \quad \rightarrow \quad \delta U = \vec{R} \bullet \delta\vec{r}$				
10.4: Applications of the Principle of Virtual Work $x_B = 2\ell\sin\theta \quad y_C = \ell\cos\theta$ $\delta x_B = 2\ell\cos\theta\delta\theta \quad \delta y_C = -\ell\sin\theta\delta\theta$ $\delta U = \delta U_Q + \delta U_P = -Q\delta x_B - P\delta y_C$ $= -2Q\ell\cos\theta\ \delta\theta + P\ell\sin\theta\ \delta\theta$ $\delta U = 0 \quad \rightarrow$ $2Q\ell\cos\theta\ \delta\theta = P\ell\sin\theta\ \delta\theta \quad \rightarrow \quad Q = \frac{1}{2}P\tan\theta$ $B_x = -\frac{1}{2}P\tan\theta$				
10.5: Real Machines. Mechanical Efficiency $\delta U = -Q\delta x_B - P\delta y_C - F\delta x_B$ $= -2Q\ell\cos\theta\ \delta\theta + P\ell\sin\theta\ \delta\theta - \mu P\ell\cos\theta\ \delta\theta$ $\delta U = 0 \quad \rightarrow \quad 2Q\ell\cos\theta\ \delta\theta = P\ell\sin\theta\ \delta\theta - \mu P\ell\cos\theta\ \delta\theta \quad \rightarrow$ $\eta = \frac{\text{output work}}{\text{input work}} = \frac{2Q\ell\cos\theta\ \delta\theta}{P\ell\sin\theta\ \delta\theta}$ $\eta = \frac{2\left(\frac{1}{2}P(\tan\theta - \mu)\right)\ell\cos\theta\ \delta\theta}{P\ell\sin\theta\ \delta\theta} = \frac{P(\tan\theta - \mu)\ell\cos\theta\ \delta\theta}{P\ell\sin\theta\ \delta\theta} = 1 - \mu\cot\theta$				

Statics Topics List (Continued).

Engineering Subject: Statics				
Engineering Analytic Topics & Typical Formulas	**Math & Science Pre-requisite Topics & Completion Grade (Georgia Performance Standard Code)** **[Pre-requisite Math Skills/Science Principles] (GPS Code) → Grade (Table No.)**		**Possible Grade to Start the Topic**	
	Math	**Physics**	**Sec**	**Ch**
Chapter 10: Method of Virtual Work (Continued)				
10.6: Work of a Force during a Finite Displacement $dU = \vec{F} \bullet d\vec{r} \quad \rightarrow \quad U_{1\to 2} = \int_{A_1}^{A_2} \vec{F} \bullet d\vec{r}$ $dU = F\,ds \cos\alpha \quad \rightarrow \quad U_{1\to 2} = \int_{S_1}^{S_2} (F\cos\alpha) ds$ $dU = M d\theta \quad \rightarrow \quad U_{1\to 2} = \int_{\theta_1}^{\theta_2} M\ d\theta \quad U_{1\to 2} = M(\theta_2 - \theta_1)$ Work of a weight $dU = -W\,dy \quad \rightarrow \quad U_{1\to 2} = -\int_{y_1}^{y_2} W\,dy \quad U_{1\to 2} = -W(y_2 - y_1) = -W$ Work of the force exerted by a spring $F = kx \quad \rightarrow \quad dU = -F\,dx = -kx\,dx$ $U_{1\to 2} = -\int_{x_1}^{x_2} kx\,dx = \frac{1}{2}kx_1^2 - \frac{1}{2}kx_2^2 \quad U_{1\to 2} = -\frac{1}{2}(F_1 + F_2)\Delta x$	[integration] → 12th (to be taught) [differentiation] → 12th (to be taught) [trigonometric functions] (MA2G2) → 10th (2F) → To be taught as a special math topic [dot product] → To be taught as a special math topic [coordinate system] (M4G3) → 4th (2B) [partial differentiation] → 12th (to be taught)	[force] (S4P3) → 4th (3A) or (S8P3) → 8th (3C) [work] (S8P3) → 8th (3C) [potential energy] (SP3) → 9th (3C)	PS	PS
10.7: Potential Energy $U_{1\to 2} = (V_g)_1 - (V_g)_2 \quad \leftarrow \quad V_g = Wy$ $U_{1\to 2} = (V_e)_1 - (V_e)_2 \quad \leftarrow \quad V_e = \frac{1}{2}kx^2$ $dU = -dV \quad U_{1\to 2} = V_1 - V_2$				

Statics Topics List (Continued).

Engineering Subject: Statics				
Engineering Analytic Topics & Typical Formulas	**Math & Science Pre-requisite Topics & Completion Grade (Georgia Performance Standard Code)** **[Pre-requisite Math Skills/Science Principles] (GPS Code) → Grade (Table No.)**		**Possible Grade to Start the Topic**	
	Math	**Physics**	**Sec**	**Ch**
Chapter 10: Method of Virtual Work (Continued)				
10.8: Potential Energy and Equilibrium $\frac{dV}{d\theta}=0 \quad V_e=\frac{1}{2}kx_B^2 \quad V_g=Wy_C \quad x_B=2\ell\sin\theta \quad y_C=\ell\cos\theta$ $V_e=\frac{1}{2}k(2\ell\sin\theta)^2 \quad V_g=W(\ell\cos\theta)$ $V=V_e+V_g=2k\ell^2\sin^2\theta+W\ell\cos\theta$ $\frac{dV}{d\theta}=4k\ell^2\sin\theta\cos\theta-W\ell\sin\theta=0$ $\frac{dV}{d\theta}=\ell\sin\theta(4k\ell\cos\theta-W)=0$	[integration] → 12th (to be taught) [differentiation] → 12th (to be taught) [trigonometric functions] (MA2G2) → 10th (2F) → To be taught as a special math topic [dot product] → To be taught as a special math topic [coordinate system] (M4G3) → 4th (2B) [partial differentiation] → 12th (to be taught)	[force] (S4P3) → 4th (2A) or (S8P3) → 8th (3C) [work] (S8P3) → 8th (3C) [potential energy] (SP3) → 9th (3C)	PS	PS
10.9: Stability of Equilibrium $\frac{dV}{d\theta}=0 \quad \frac{d^2V}{d\theta^2}>0$: stable equilibrium $\frac{dV}{d\theta}=0 \quad \frac{d^2V}{d\theta^2}<0$: unstable equilibrium $\frac{\partial V}{\partial\theta_1}=\frac{\partial V}{\partial\theta_2}=0 \quad \left(\frac{\partial^2V}{\partial\theta_1\partial\theta_2}\right)^2-\frac{\partial^2V}{\partial\theta_1^2}\frac{\partial^2V}{\partial\theta_2^2}<0$ $\frac{\partial^2V}{\partial\theta_1^2}>0$ or $\frac{\partial^2V}{\partial\theta_2^2}>0$				
TE END				

Part Two
1st Round of Delphi –
Five-Point Likert Scale Survey Forms

Proposed Procedures for Survey Response

To facilitate survey response to the initial selection of statics topics that could be possibly taught to students at 9th or above Grade, as listed in the *Statics Survey Form A* and *Survey Form B*, the following procedures are hereby proposed:

1. Rate the importance of each Section as a topic in a potentially viable 9th or above Grade statics subject, and write a number representing its "importance" value (*Figure 4A*), using the five-point Likert Scale (*Figure 4B*);

2. Check the formulas listed under the **Engineering Analytic Topics & Typical Formulas** column, and use symbols shown in *Figure 4B* to indicate your expert opinion and advice about each formula;

3. Add your general comments and advice in the empty space.

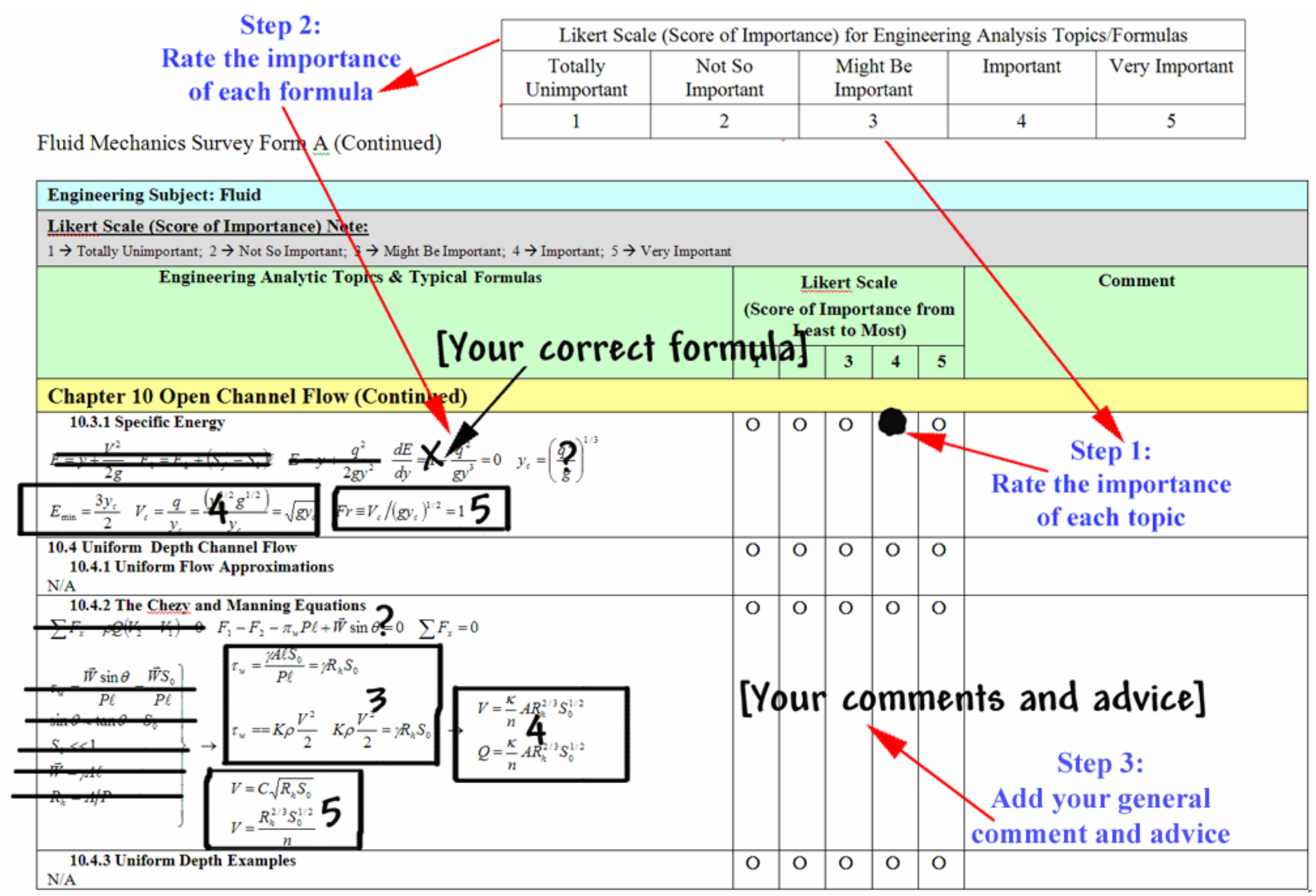


Figure 4A. *Step-by-step procedures proposed for the review and validation of data.*

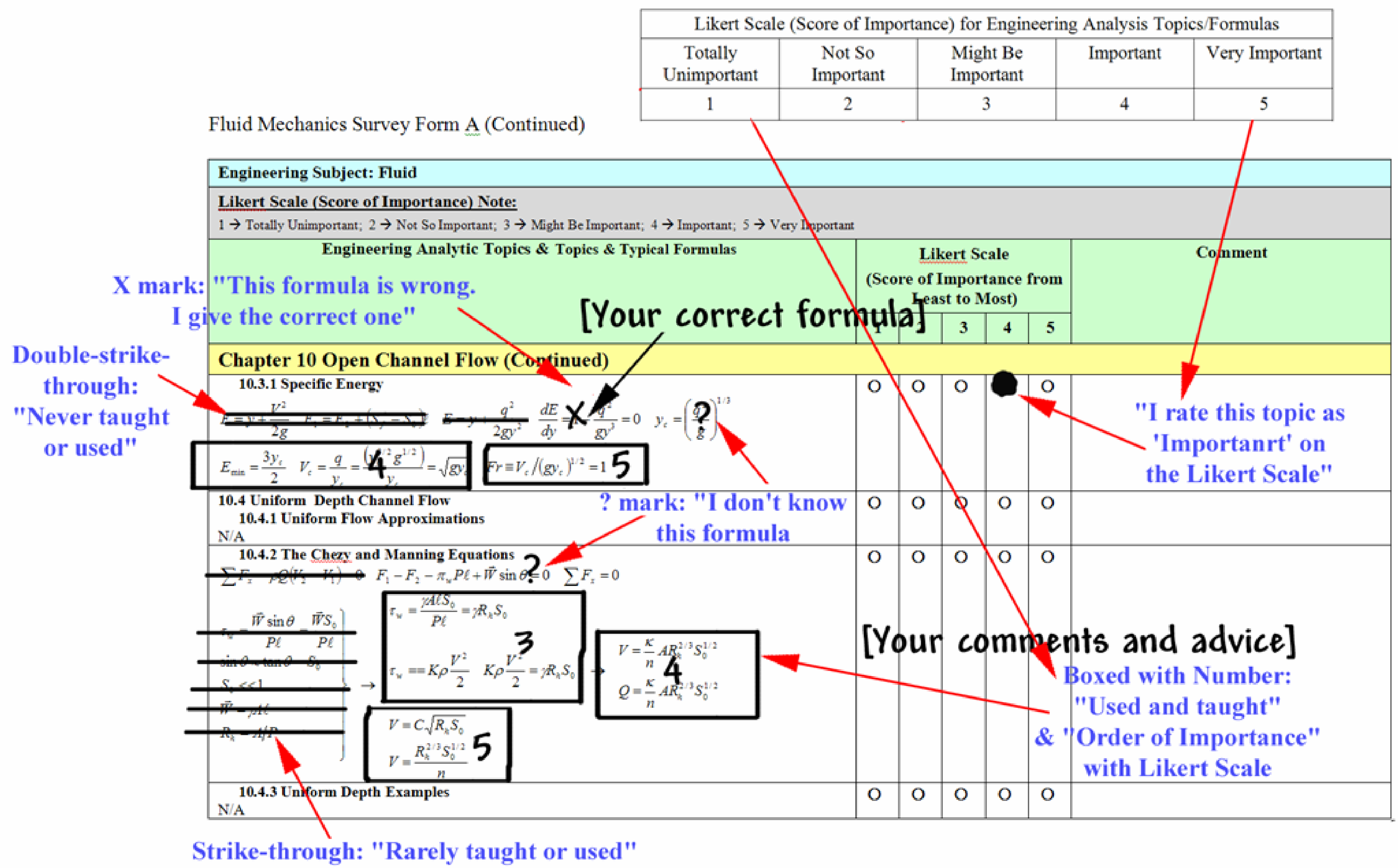
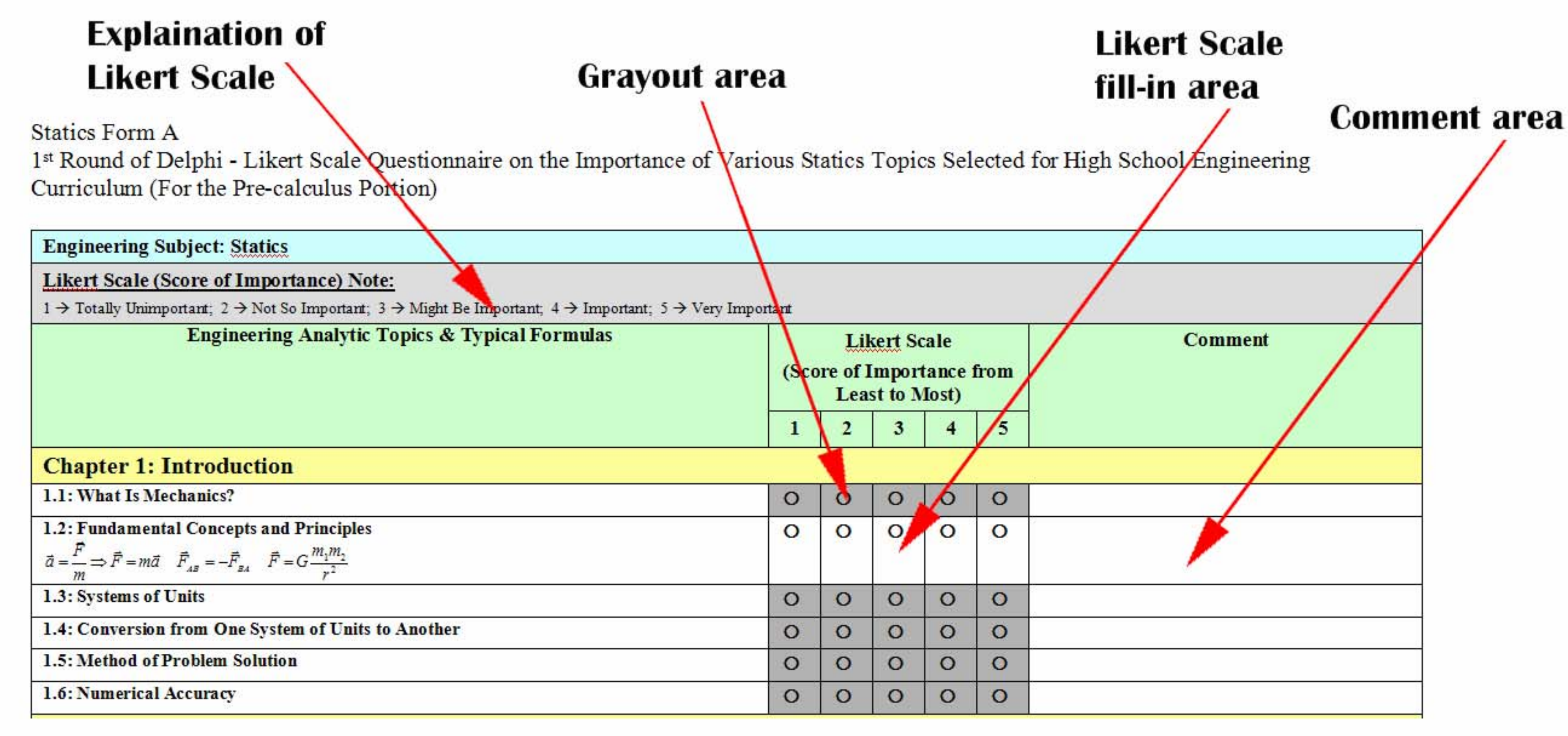


Figure 4B. Likert Scale (top) and symbols to be used for the expression of expert opinion and offer of advice.



Statics Form A
1st Round of Delphi - Likert Scale Questionnaire on the Importance of Various Statics Topics Selected for High School Engineering Curriculum (For the Pre-calculus Portion)

Engineering Subject: Statics						
Likert Scale (Score of Importance) Note: 1 → Totally Unimportant; 2 → Not So Important; 3 → Might Be Important; 4 → Important; 5 → Very Important						
Engineering Analytic Topics & Typical Formulas	**Likert Scale (Score of Importance from Least to Most)**					**Comment**
	1	2	3	4	5	
Chapter 1: Introduction						
1.1: What Is Mechanics?	O	O	O	O	O	
1.2: Fundamental Concepts and Principles $\vec{a}=\frac{\vec{F}}{m}\Rightarrow\vec{F}=m\vec{a}$ $\vec{F}_{AB}=-\vec{F}_{BA}$ $\vec{F}=G\frac{m_1m_2}{r^2}$	O	O	O	O	O	
1.3: Systems of Units	O	O	O	O	O	
1.4: Conversion from One System of Units to Another	O	O	O	O	O	
1.5: Method of Problem Solution	O	O	O	O	O	
1.6: Numerical Accuracy	O	O	O	O	O	

Figure 4C. Gray-out rows.

Notice that in *Statics Form A* and *Statics Form B*, some rows under the **Likert Scale (Score of Importance from Least to Most)** columns are gray-out (*Figure 4C*). These gray-out rows correspond to some topics of statics that are so essential that they need to be included into a potentially viable K-12 statics curriculum in order to maintain the integrity of its pre-requisite sequence. The participants could still choose to rate their Likert Scale order of importance to help better understand their different roles in a potentially viable K-12 statics course.

Notes about the Statics Analytic Principles and Formulas

The leftmost column in the *Statics Survey Form A* and *Statics Survey Form B* contain

1. The titles of each section under a particular chapter in the selected textbook, which in general represent particular sets of statics related engineering analytic and predictive principles, in a qualitative and explanatory way;

2. Computational formulas, which symbolically represent the above engineering analytic and predictive principles, in a quantitative and mathematical way.

As shown in *Figure 4B*, the formulas extracted from the selected textbook might by categorized into five groups, corresponding to the five different symbols shown in *Figure 4B*, which could be used by the above-mentioned five Groups of Participants:

1. <u>Formulas that engineering professors actually teach in classroom lectures and that practicing engineers use in engineering design projects</u>: These are the important ones to be included in a potentially viable K-12 engineering curriculum that shall be based on cohesive and systemic mastery of engineering analytic and predictive principles and skills. For any of these formulas, a box could be used together with a number representing its order of importance according to the five-point Likert Scale (1 = Totally Unimportant, 2 = Not So Important, 3 = Might Be Important, 4 = Important, or 5 = Very Important).

2. <u>Formulas that are rarely used in either classroom lectures or in field practice, but are used by the original discoverer of a particular set of analytic principles to derive other formulas that are actually used in classroom lecture or in field practice</u>: Some of these "intermediate" formulas might not be used often, in other words, they are "rarely taught or used." For any of these formulas, a strikethrough could be used. If a big enough percentage of participants (maybe 85% or above) place a strikethrough on a particular formula at the end of each round of the proposed four-round Delphi study, then the formula will be removed from the survey form for the next round. If the trend continues through all four rounds of the proposed Delphi survey, then that formula might be removed from the final list of high school appropriate statics topics. Interestingly enough, in some cases, rarely used calculus-based "intermediate" formulas are used to derive a final one that is based on pre-calculus mathematics skills and is actually used in most homework assignments and design projects; in this case, if the

"intermediate" formulas are removed from consideration, then the entire topic of statics could be re-classified as appropriate for 9th Grade. For example, in fluid mechanics, the main formula $\vec{F} = m\vec{a}$ and $p + \frac{1}{2}\rho V^2 + \gamma z =$ constant along a streamline (Bernoulli Equation) do not need calculus, and thus, could be taught to 9th Grade students. This type of formulas will make the list shorter and shorter as the proposed Delphi study moves to the next round of survey. Some of these formulas might not be in the selected textbook; I derived them for fun, sometimes with the help of my former engineering professor, Dr. Dr. Jayesh Bhakta, at Los Angeles City College.

3. <u>Formulas that are particular to certain conditions and in real classroom lectures or field practice are, for all practical purposes, close to be "never used</u>:" For any of these formulas, a double-strikethrough could be used. If a big enough percentage of participants (maybe 75% or above) place a double-strikethrough on a particular formula at the end of each round of the proposed four-round Delphi study, then the formula will be removed from the survey form for the next round. If the trend continues through all four rounds of the proposed Delphi survey, then that formula might be removed from the final list of high school appropriate statics topics. This type of formulas will also make the list shorter and shorter as the proposed Delphi study moves to the next round of survey.

4. <u>Formulas that even experienced university engineering professors or practicing engineers might "not understand</u>:" This is amazing but totally correct and yes, absolutely normal! There are formulas that even experienced professors might say "I do not understand this" or "I need to read the context in the book to figure this out." For any of these formulas, the participants should generally not seek to understand them (doing so does not serve the purpose of studying the relative importance of each computational formula); but instead, a question mark (?) could be used. If a big enough percentage of participants (maybe 65% or above) place a question mark (?) on a particular formula at the end of each round of the proposed four-round Delphi study, then the formula will be removed from the survey form for the next round. If the trend continues through all four rounds of the proposed Delphi survey, then that formula might be removed from the final list of high school appropriate statics topics. Indeed, it makes little sense to include this type of formulas to a potentially viable K-12 engineering curriculum. This type of formulas will also make the list shorter and shorter as the proposed Delphi study moves to the next round of survey. Some of these formulas might not be in the selected textbook; I derived them for fun, sometimes with the help of my former engineering professor, Dr. Jayesh Bhakta, at Los Angeles City College.

6. Formulas that are wrong for any reasons (my typing errors, or the authors' errors, etc.): For any of these formulas, a cross (X) could be used and the correct formulas should be given if possible. The correction would be included in the survey forms for the subsequent rounds of the four-round five-point Likert Scale Delphi study.

For convenience of statistic analysis of expert opinions and advice, it is requested that all participants print each letter of their comment legibly and separately, using fonts commonly used in engineering notebooks.

Statics Survey Form A
1st Round of Delphi - Likert Scale Questionnaire on the Importance of Various Statics Topics Selected for High School Engineering Curriculum (For the Pre-calculus Portion)

Engineering Subject: Statics						
Likert Scale (Score of Importance) Note: 1 → Totally Unimportant; 2 → Not So Important; 3 → Might Be Important; 4 → Important; 5 → Very Important						
Engineering Analytic Topics & Typical Formulas	**Likert Scale (Score of Importance from Least to Most)**					**Comment**
	1	**2**	**3**	**4**	**5**	
Chapter 1: Introduction						
1.1: What Is Mechanics?	○	○	○	○	○	
1.2: Fundamental Concepts and Principles $\vec{a} = \frac{\vec{F}}{m} \Rightarrow \vec{F} = m\vec{a}$ $\vec{F}_{AB} = -\vec{F}_{BA}$ $\vec{F} = G\frac{m_1 m_2}{r^2}$	○	○	○	○	○	
1.3: Systems of Units	○	○	○	○	○	
1.4: Conversion from One System of Units to Another	○	○	○	○	○	
1.5: Method of Problem Solution	○	○	○	○	○	
1.6: Numerical Accuracy	○	○	○	○	○	
Chapter 2: Statics of Particles						
2.1: Introduction	○	○	○	○	○	
Forces in a Plane **2.2: Force on a Particle. Resultant of Two Forces**	○	○	○	○	○	
2.3: Vectors	○	○	○	○	○	
2.4: Addition of Vectors	○	○	○	○	○	
2.5: Resultant of Several Concurrent Forces	○	○	○	○	○	
2.6: Resolution of a Force into Components	○	○	○	○	○	
2.7: Rectangular Components of a Force. Unit Vectors	○	○	○	○	○	

Statics Survey Form A (Continued).

Engineering Subject: Statics						
Likert Scale (Score of Importance) Note: 1 → Totally Unimportant; 2 → Not So Important; 3 → Might Be Important; 4 → Important; 5 → Very Important						
Engineering Analytic Topics & Typical Formulas	**Likert Scale (Score of Importance from Least to Most)**					**Comment**
	1	**2**	**3**	**4**	**5**	
Chapter 2: Statics of Particles (Continued)						
2.8: Addition of Forces by Summing *x* and *y* Components $\vec{F} = F_x\hat{i} + F_y\hat{j}$ $F_x = F\cos\theta$ $F_y = F\sin\theta$ $\tan\theta = \frac{F_y}{F_x}$ $F = \sqrt{F_x^2 + F_y^2}$	○	○	○	○	○	
2.9: Equilibrium of a Particle $R = \sum F = F_1 + F_2 + ... = 0 \Rightarrow R_x = \sum F_x = 0$ $R_y = \sum F_y = 0$ $R_z = \sum F_z = 0$	○	○	○	○	○	
2.10: Newton's First Law of Motion	○	○	○	○	○	
2.11: Problems Involving the Equilibrium of a Particle. Free-Body Diagrams	○	○	○	○	○	
Forces in Space **2.12: Rectangular Components of a Force in Space** $F_y = F\cos\theta_y$ $F_h = F\sin\theta_y$ $F_x = F_h\cos\phi = F\sin\theta_y\cos\phi$ $F_z = F_h\sin\phi = F\sin\theta_y\sin\phi$ $F^2 = F_y + F_h = F_y + F_x + F_z \rightarrow F = \sqrt{F_x + F_y + F_z}$ $F_x = F\cos\theta_x$ $F_y = F\cos\theta_y$ $F_z = F\cos\theta_z$ $(0^\circ < \theta_{x,y,z} < 180^\circ)$ $\vec{F} = F_x\hat{i} + F_y\hat{j} + F_z\hat{k}$ $\vec{F} = F(\cos\theta_x\hat{i} + \cos\theta_y\hat{j} + \cos\theta_z\hat{k})$ $\cos\theta_x = \frac{F_x}{F} = \frac{d_x}{d} = \frac{R_x}{R}$ $\cos\theta_y = \frac{F_y}{F} = \frac{d_y}{d} = \frac{R_y}{R}$ $\cos\theta_z = \frac{F_z}{F} = \frac{d_z}{d} = \frac{R_z}{R}$ $\theta_{x(y,z)} = \cos^{-1}\frac{F_{x(y,z)}}{F} = \cos^{-1}\frac{d_{x(y,z)}}{d}$ $F = \sqrt{F_x^2 + F_y^2 + F_z^2}$ $\hat{\lambda} = \cos\theta_x\hat{i} + \cos\theta_y\hat{j} + \cos\theta_z\hat{k}$ $\hat{\lambda} = \frac{\vec{F}}{F}$ $\hat{i} = \frac{d_x}{d}$ $\hat{j} = \frac{d_y}{d}$ $\hat{k} = \frac{d_z}{d}$ $\cos^2\theta_x + \cos^2\theta_y + \cos^2\theta_z = 1 \rightarrow \hat{\lambda}_x^2 + \hat{\lambda}_y^2 + \hat{\lambda}_z^2 = 1$	○	○	○	○	○	

Statics Survey Form A (Continued).

Engineering Subject: Statics						
Likert Scale (Score of Importance) Note: 1 → Totally Unimportant; 2 → Not So Important; 3 → Might Be Important; 4 → Important; 5 → Very Important						
Engineering Analytic Topics & Typical Formulas	**Likert Scale (Score of Importance from Least to Most)**					**Comment**
	1	**2**	**3**	**4**	**5**	
Chapter 2: Statics of Particles (Continued)						
2.13: Force Defined by Its Magnitude and Two Points on Its Line of Action $\overrightarrow{MN} = d_x\hat{i} + d_y\hat{j} + d_z\hat{k}$ $\hat{\lambda} = \frac{\overrightarrow{MN}}{MN} = \frac{1}{d}\left(d_x\hat{i} + d_y\hat{j} + d_z\hat{k}\right)$ $d_{x(y,z)} = x(y,z)_2 - x(y,z)_1$ $d = \sqrt{d_x^2 + d_y^2 + d_z^2}$ $\vec{F} = F\hat{\lambda} = \frac{F}{d}\left(d_x^2\hat{i} + d_y^2\hat{j} + d_z^2\hat{k}\right)$ $F_x = \frac{Fd_x}{d}$ $F_y = \frac{Fd_y}{d}$ $F_z = \frac{Fd_z}{d}$	○	○	○	○	○	
2.14: Addition of Concurrent Forces in Space $\vec{R} = \sum\vec{F}$ $R = \sqrt{R_x^2 + R_y^2 + R_z^2}$ $R_x\hat{i} + R_y\hat{j} + R_z\hat{k} = \left(\sum F_x\right)\hat{i} + \left(\sum F_y\right)\hat{j} + \left(\sum F_z\right)\hat{k}$	○	○	○	○	○	
2.15: Equilibrium of a Particle in Space $R = \sum F = F_1 + F_2 + ... = 0 \rightarrow R_x = \sum F_x = 0$ $R_y = \sum F_y = 0$ $R_z = \sum F_z = 0$ $\begin{bmatrix} a & b & c \\ d & e & f \\ g & h & i \end{bmatrix} \times \begin{bmatrix} x \\ y \\ z \end{bmatrix} = \begin{bmatrix} ax + by + cz \\ dx + ey + fz \\ gx + hy + iz \end{bmatrix}$ $\begin{bmatrix} a & b & c \\ d & e & f \\ g & h & i \end{bmatrix} \times \begin{bmatrix} F_1 \\ F_2 \\ F_3 \end{bmatrix} = \begin{bmatrix} 0 \\ 0 \\ 0 \end{bmatrix}$ $\begin{matrix} R_x = \sum F_x = 0 & aF_1 + bF_2 + cF_3 = 0 \\ R_y = \sum F_y = 0 & dF_1 + eF_2 + fF_3 = 0 \\ R_z = \sum F_z = 0 & gF_1 + hF_2 + iF_3 = 0 \end{matrix}$ $\begin{bmatrix} a & b & c \\ d & e & f \\ g & h & i \end{bmatrix} \times \begin{bmatrix} F_1 \\ F_2 \\ F_3 \end{bmatrix} = \begin{bmatrix} aF_1 + bF_2 + cF_3 \\ dF_1 + eF_2 + fF_3 \\ gF_1 + hF_2 + iF_3 \end{bmatrix}$	○	○	○	○	○	

Statics Survey Form A (Continued).

Engineering Subject: Statics						
Likert Scale (Score of Importance) Note: 1 → Totally Unimportant; 2 → Not So Important; 3 → Might Be Important; 4 → Important; 5 → Very Important						
Engineering Analytic Topics & Typical Formulas	**Likert Scale (Score of Importance from Least to Most)**					**Comment**
	1	**2**	**3**	**4**	**5**	
Chapter 3: Rigid Bodies - Equivalent Systems of Forces						
3.1: Introduction	○	○	○	○	○	
3.2: External and Internal Forces	○	○	○	○	○	
3.3: Principle of Transmissibility. Equivalent Forces	○	○	○	○	○	
3.4: Vector Product of Two Vectors $\vec{V}=\vec{P}\times\vec{Q}$ $V=PQ\sin\theta$ $\vec{V}\perp\vec{P}$ $\vec{V}\perp\vec{Q}$ $\vec{V}\perp Plane_{\vec{P},\vec{Q}}$ $\vec{P}\times(\vec{Q}_1+\vec{Q}_2)=\vec{P}\times\vec{Q}_1+\vec{P}\times Q_2$ $(\vec{P}\times\vec{Q})\times\vec{S}\neq\vec{P}\times(\vec{Q}\times\vec{S})$ $\vec{V}=\vec{Q}\times\vec{P}=-(\vec{P}\times\vec{Q})$ $\vec{Q}\times\vec{P}\neq\vec{P}\times\vec{Q}$ $\vec{P}\times\vec{Q}=-\vec{V}$ $\vec{P}\times(\vec{Q}_1+Q_2)=\vec{P}\times\vec{Q}_1+\vec{P}\times Q_2$ $\vec{Q}\times\vec{P}\neq\vec{P}\times\vec{Q}$ $\vec{V}=\vec{Q}\times\vec{P}=-(\vec{P}\times\vec{Q})$ $\vec{P}\times\vec{Q}=-\vec{V}$ $\vec{V}=\vec{P}\times\vec{Q}$ $(\vec{P}\times\vec{Q})\times\vec{S}\neq\vec{P}\times(\vec{Q}\times\vec{S})$	○	○	○	○	○	
3.5: Vector Products Expressed in Terms of Rectangular Components $\hat{i}\times\hat{i}=\hat{j}\times\hat{j}=\hat{k}\times\hat{k}=0$ $\hat{i}\times\hat{j}=\hat{k}$ $\hat{j}\times\hat{k}=\hat{i}$ $\hat{k}\times\hat{i}=\hat{j}$ $\hat{i}\times\hat{k}=-\hat{j}$ $\hat{j}\times\hat{i}=-\hat{k}$ $\hat{k}\times\hat{j}=-\hat{i}$ $\vec{P}=P_x\hat{i}+P_y\hat{j}+P_z\hat{k}$ $\vec{Q}=Q_x\hat{i}+Q_y\hat{j}+Q_z\hat{k}$ $\vec{V}=\vec{P}\times\vec{Q}=\begin{vmatrix}\hat{i}&\hat{j}&\hat{k}\\P_x&P_y&P_z\\Q_x&Q_y&Q_z\end{vmatrix}=V_x\hat{i}+V_y\hat{j}+V_z\hat{k}$ $V_x=P_yQ_z-P_zQ_y$ $V_y=-(P_xQ_z-P_zQ_x)=P_zQ_x-P_xQ_z$ $V_z=P_xQ_y-P_yQ_x$	○	○	○	○	○	
3.6: Moment of a Force about a Point $\vec{M}_0=\vec{r}\times\vec{F}$ $M_0=rF\sin\theta=Fd$ $\vec{r}=\vec{v}_{position}^{O\to A}$ $\theta=\angle_{\vec{r}\to\vec{F}}$ $d\perp\vec{F}$ $\vec{M}_0=\vec{r}\times\vec{F}=\begin{vmatrix}\hat{i}&\hat{j}&\hat{k}\\x&y&z\\F_x&F_y&F_z\end{vmatrix}=M_x\hat{i}+M_y\hat{j}+M_z\hat{k}$ $M_x=yF_z-zF_y$ $M_y=-(xF_z-zF_x)=zF_x-xF_z$ $M_z=xF_y-yF_x$	○	○	○	○	○	

Statics Survey Form A (Continued).

Engineering Subject: Statics						
Likert Scale (Score of Importance) Note: 1 → Totally Unimportant; 2 → Not So Important; 3 → Might Be Important; 4 → Important; 5 → Very Important						
Engineering Analytic Topics & Typical Formulas	**Likert Scale (Score of Importance from Least to Most)**					**Comment**
	1	**2**	**3**	**4**	**5**	
Chapter 3: Rigid Bodies - Equivalent Systems of Forces (Continued)						
3.7: Varignon's Theorem $\vec{r}\times\left(\vec{F}_1+\vec{F}_2+\ldots\right)=\vec{r}\times\vec{F}_1+\vec{r}\times\vec{F}_2+\ldots$	○	○	○	○	○	
3.8: Rectangular Components of the Moment of a Force $\vec{M}_B=\vec{r}_{A/B}\times\vec{F}=\begin{vmatrix}\hat{i} & \hat{j} & \hat{k}\\ x_{A/B} & y_{A/B} & z_{A/B}\\ F_x & F_y & F_z\end{vmatrix}$ $\vec{r}_{A/B}=x_{A/B}\hat{i}+y_{A/B}\hat{j}+z_{A/B}\hat{k}$ $x_{A/B}=x_A-x_B$ $y_{A/B}=y_A-y_B$ $z_{A/B}=z_A-z_B$	○	○	○	○	○	
3.9: Scalar Product of Two Vectors $\vec{P}\bullet\vec{Q}=PQ\cos\theta=P_xQ_x+P_yQ_y+P_zQ_z \quad \theta=\angle_{\vec{P}\to\vec{Q}}$ $\vec{P}\bullet\vec{Q}=\vec{Q}\bullet\vec{P} \quad \vec{P}\bullet\left(\vec{Q}_1+\vec{Q}_2\right)=\vec{P}\bullet\vec{Q}_1+\vec{P}\bullet\vec{Q}_2 \quad P_{OL}=\vec{P}\bullet\hat{\lambda}=P_x\cos\theta_x+P_y\cos\theta_y+P_z\cos\theta_z$ (More formulas on p. pp. 94-95)	○	○	○	○	○	
3.10: Mixed Triple Product of Three Vectors $\vec{S}\bullet\left(\vec{P}\times\vec{Q}\right)=\begin{vmatrix}S_x & S_y & S_z\\ P_x & P_y & P_z\\ Q_x & Q_y & Q_z\end{vmatrix}$	○	○	○	○	○	

Statics Survey Form A (Continued).

Engineering Subject: Statics						
Likert Scale (Score of Importance) Note: 1 → Totally Unimportant; 2 → Not So Important; 3 → Might Be Important; 4 → Important; 5 → Very Important						
Engineering Analytic Topics & Typical Formulas	**Likert Scale (Score of Importance from Least to Most)**					**Comment**
	1	**2**	**3**	**4**	**5**	
Chapter 3: Rigid Bodies - Equivalent Systems of Forces (Continued)						
3.11: Moment of a Force about a Given Axis $M_{OL} = \hat{\lambda} \bullet \vec{M}_O = \hat{\lambda} \bullet \left(\vec{r} \times \vec{F}\right) = \begin{vmatrix} \lambda_x & \lambda_y & \lambda_z \\ x & y & z \\ F_x & F_y & F_z \end{vmatrix}$ (More formulas on p. pp. 98)	○	○	○	○	○	
3.12: Moment of a Couple $\vec{M} = \vec{r} \times \vec{F} \quad M = rF\sin\theta = Fd$	○	○	○	○	○	
3.13: Equivalent Couples $F_1 d_1 = F_2 d_2$	○	○	○	○	○	
3.14: Addition of Couples $\vec{M} = \vec{r} \times \vec{R} = \vec{r} \times \left(\vec{F}_1 + \vec{F}_2\right) = \vec{r} \times \vec{F}_1 + \vec{r} \times \vec{F}_2 \quad \vec{M} = \vec{M}_1 + \vec{M}_2$	○	○	○	○	○	
3.15: Couples Can Be Represented by Vectors	○	○	○	○	○	
3.16: Resolution of a Given Force Into a Force at *O* and a Couple $\vec{M}_{O'} = \vec{r}' \times \vec{F} = \left(\vec{r} + \vec{s}\right) \times \vec{F} = \vec{r} \times \vec{F} + \vec{s} \times \vec{F} \quad \vec{M}_{O'} = \vec{M}_O + \vec{s} \times \vec{F}$	○	○	○	○	○	
3.17: Reduction of a System of Forces to One Force and One Couple $\vec{R} = \sum \vec{F} \quad \vec{M}_O^R = \sum \vec{M}_O = \sum \left(\vec{r} \times \vec{F}\right) \quad \vec{M}_{O'}^R = \vec{M}_O + \vec{s} \times \vec{R} \quad \vec{r} = x\hat{i} + y\hat{j} + z\hat{k}$ $\vec{F} = F_x\hat{i} + F_y\hat{j} + F_z\hat{k} \quad \vec{R} = R_x\hat{i} + R_y\hat{j} + R_z\hat{k} \quad \vec{M}_O^R = M_x^R\hat{i} + M_y^R\hat{j} + M_z^R\hat{k}$	○	○	○	○	○	

Statics Survey Form A (Continued).

Engineering Subject: Statics						
Likert Scale (Score of Importance) Note: 1 → Totally Unimportant; 2 → Not So Important; 3 → Might Be Important; 4 → Important; 5 → Very Important						
Engineering Analytic Topics & Typical Formulas	**Likert Scale (Score of Importance from Least to Most)**					**Comment**
	1	**2**	**3**	**4**	**5**	
Chapter 3: Rigid Bodies - Equivalent Systems of Forces (Continued)						
3.18: Equivalent Systems of Forces $\sum \vec{F} = \sum \vec{F}'$ & $\sum \vec{M}_0 = \sum \vec{M}'_0$ $\sum \vec{F} = \sum \vec{F}'$ *and* $\sum \vec{M}_O = \vec{M}_O'$ $\sum F_x = \sum F'_x$ $\sum F_y = \sum F'_y$ $\sum F_z = \sum F'_z$ $\sum M_x = \sum M'_x$ $\sum M_y = \sum M'_y$ $\sum M_z = \sum M'_z$	○	○	○	○	○	
3.19: Equipollent Systems of Vectors	○	○	○	○	○	
3.20: Further Reduction of a System of Forces	○	○	○	○	○	
3.21: Reduction of a System of Forces to a Wrench $p = \frac{M_1}{R}$ $M_1 = \frac{\vec{R} \bullet \vec{M}_O^R}{R}$ $p = \frac{M_1}{R} = \frac{\vec{R} \bullet \vec{M}_O^R}{R^2}$ $\vec{M}_1 = p\vec{R} \rightarrow$ $\vec{M}_1 + \vec{r} \times \vec{R} = \vec{M}_O^R$ $p\vec{R} + \vec{r} \times \vec{R} = \vec{M}_O^R$	○	○	○	○	○	
Chapter 4: Equilibrium of Rigid Bodies						
4.1: Introduction $\sum \vec{F} = 0$ $\sum F_x = 0$ $\sum F_y = 0$ $\sum F_z = 0$ $\sum \vec{M}_O = \sum (\vec{r} \times \vec{F}) = 0$ $\sum M_x = 0$ $\sum M_y = 0$ $\sum M_z = 0$	○	○	○	○	○	
4.2: Free-Body Diagram	○	○	○	○	○	
Equilibrium in Two Dimensions **4.3: Reactions at Supports and Connections for a Two-Dimensional Structure**	○	○	○	○	○	
4.4: Equilibrium of a Rigid Body in Two Dimensions $F_z = 0$ $M_x = M_y = 0$ $M_z = M_O$ $\sum F_x = 0$ $\sum F_y = 0$ $\sum M_O = 0$ $\sum M_A = 0$ $\sum M_B = 0$ $\sum M_C = 0$	○	○	○	○	○	

Statics Survey Form A (Continued).

Engineering Subject: Statics						
Likert Scale (Score of Importance) Note: 1 → Totally Unimportant; 2 → Not So Important; 3 → Might Be Important; 4 → Important; 5 → Very Important						
Engineering Analytic Topics & Typical Formulas	**Likert Scale (Score of Importance from Least to Most)**					**Comment**
	1	**2**	**3**	**4**	**5**	
Chapter 4: Equilibrium of Rigid Bodies (Continued)						
4.5: Statically Indeterminate Reactions. Partial Constraints	○	○	○	○	○	
4.6: Equilibrium of a Two-Force Body	○	○	○	○	○	
4.7: Equilibrium of a Three-Force Body	○	○	○	○	○	
Equilibrium in Three Dimensions **4.8: Equilibrium of a Rigid Body in Three Dimensions** $\sum \vec{F} = 0 \quad \sum \vec{M}_O = \sum(\vec{r} \times \vec{F}) = 0 \quad \sum F_x = 0 \quad \sum F_y = 0 \quad \sum F_z = 0 \quad \sum M_x = 0 \quad \sum M_y = 0 \quad \sum M_z = 0$	○	○	○	○	○	
4.9: Reactions at Supports and Connections for a Three-Dimensional Structure	○	○	○	○	○	
Chapter 6: Analysis of Structures						
6.1: Introduction	○	○	○	○	○	
Trusses **6.2: Definition of a Truss**	○	○	○	○	○	
6.3: Simple Trusses	○	○	○	○	○	
6.4: Analysis of Trusses by the Method of Joints	○	○	○	○	○	
6.5: Joints under Special Loading Conditions	○	○	○	○	○	
6.6: Space Trusses	○	○	○	○	○	
6.7: Analysis of Trusses by the Method of Sections	○	○	○	○	○	
6.8: Trusses Made of Several Simple Trusses	○	○	○	○	○	

Statics Survey Form A (Continued).

Engineering Subject: Statics						
Likert Scale (Score of Importance) Note: 1 → Totally Unimportant; 2 → Not So Important; 3 → Might Be Important; 4 → Important; 5 → Very Important						
Engineering Analytic Topics & Typical Formulas	**Likert Scale (Score of Importance from Least to Most)**					**Comment**
	1	**2**	**3**	**4**	**5**	
Chapter 6: Analysis of Structures						
Frames and Machines **6.9: Structures Containing Multiforce Members**	○	○	○	○	○	
6.10: Analysis of a Frame	○	○	○	○	○	
6.11: Frames Which Cease to Be Rigid When Detached from Their Supports	○	○	○	○	○	
6.12: Machines	○	○	○	○	○	
Chapter 8: Friction						
8.1: Introduction	○	○	○	○	○	
8.2: The Laws of Dry Friction. Coefficients of Friction $F_m = \mu_s N \quad F_k = \mu_k N$	○	○	○	○	○	
8.3: Angles of Friction $\tan\phi_s = \frac{F_m}{N} = \frac{\mu_s N}{N} \rightarrow \tan\phi_s = \mu_s \quad \tan\phi_k = \frac{F_k}{N} = \frac{\mu_k N}{N} \rightarrow \tan\phi_k = \mu_k$	○	○	○	○	○	
8.4: Problems Involving Dry Friction	○	○	○	○	○	
8.5: Wedges	○	○	○	○	○	
8.6: Square-Threaded Screws $Q = P\frac{a}{r} \quad L = nP$	○	○	○	○	○	
8.7: Journal Bearings. Axle Friction $M = Rr\sin\phi_k \approx Rr\mu_k \quad r_f = r\sin\phi_k \approx r\mu_k$	○	○	○	○	○	
8.9: Wheel Friction. Rolling Resistance $\Pr = Wb$	○	○	○	○	○	
TE END						

Statics Survey Form B

1st Round of Delphi - Likert Scale Questionnaire on the Importance of Various Statics Topics Selected for High School Engineering Curriculum (For the Calculus Portion)

Engineering Subject: Statics						
Likert Scale (Score of Importance) Note: 1 → Totally Unimportant; 2 → Not So Important; 3 → Might Be Important; 4 → Important; 5 → Very Important						
Engineering Analytic Topics & Typical Formulas	**Likert Scale (Score of Importance from Least to Most)**					**Comment**
	1	**2**	**3**	**4**	**5**	
Chapter 5: Distributed Forces: Centroids and Centers of Gravity						
5.1: Introduction	○	○	○	○	○	
Areas and Lines **5.2: Center of Gravity of a Two-Dimensional Body** $Plate: \sum F_z: \ W = \Delta W_1 + \Delta W_2 + ... + \Delta W_n$ $\sum M_y: \ \bar{x}W = x_1 \Delta W + x_2 \Delta W + ... + x_n \Delta W$ $\sum M_x: \ \bar{y}W = y_1 \Delta W + y_2 \Delta W + ... + y_n \Delta W$ $W = \int dW \quad \bar{x}W = \int x dW \quad \bar{y}W = \int y dW$ $Wire: \sum M_y: \ \bar{x}W = \sum x \Delta W \quad \sum M_x: \ \bar{y}W = \sum y \Delta W$	○	○	○	○	○	
5.3: Centroids of Areas and Lines $Plate: \ \Delta W = \gamma t \Delta A \quad W = \gamma t A \quad \bar{x}A = \int x dA \quad \bar{y}A = \int y dA$ $Line: \ \Delta W = \gamma a \Delta L \quad \bar{x}L = \int x dL \quad \bar{y}L = \int y dL$	○	○	○	○	○	
5.4: First Moments of Areas and Lines $\bar{x}A = Q_y = \int x dA \quad \bar{y}A = Q_x = \int y dA$	○	○	○	○	○	
5.5: Composite Plates and Wires $\bar{X}\sum W = \sum \bar{x}W \quad \bar{Y}\sum W = \sum \bar{y}W \quad Q_y = \bar{X}\sum A = \sum \bar{x}A \quad Q_x = \bar{Y}\sum A = \sum \bar{y}A$	○	○	○	○	○	
5.6: Determination of Centroids by Integration $Q_y = \bar{x}A = \int \bar{x}_{el} dA \quad Q_x = \bar{y}A = \int \bar{y}_{el} dA$	○	○	○	○	○	

Statics Survey Form B (Continued).

Engineering Subject: Statics						
Likert Scale (Score of Importance) Note: 1 → Totally Unimportant; 2 → Not So Important; 3 → Might Be Important; 4 → Important; 5 → Very Important						
Engineering Analytic Topics & Typical Formulas	**Likert Scale (Score of Importance from Least to Most)**					**Comment**
	1	**2**	**3**	**4**	**5**	
Chapter 5: Distributed Forces: Centroids and Centers of Gravity (Continued)						
5.7: Theorems of Pappus-Guldinus $A = 2\pi\bar{y}L \quad V = 2\pi\bar{y}A$	○	○	○	○	○	
5.8: Distributed Loads on Beams $W = \int_O^L w dx \quad W = \int dA = A \quad (OP)W = \int x dW \quad (OP)A = \int_O^L x dA$	○	○	○	○	○	
5.9: Forces on Submerged Surfaces $w = bp = b\gamma h$	○	○	○	○	○	
Volumes **5.10: Center of Gravity of a Three- Dimensional Body. Centroid of a Volume** $\bar{x}W = \int x dW \quad \bar{y}W = \int y dW \quad \bar{z}W = \int z dW$ $\bar{x}V = \int x dV \quad \bar{y}V = \int y dV \quad \bar{z}V = \int z dV$	○	○	○	○	○	
5.11: Composite Bodies $\bar{X}\sum W = \sum \bar{x}W \quad \bar{Y}\sum W = \sum \bar{y}W \quad \bar{Z}\sum W = \sum \bar{z}W$ $\bar{X}\sum V = \sum \bar{x}V \quad \bar{Y}\sum V = \sum \bar{y}V \quad \bar{Z}\sum V = \sum \bar{z}V$	○	○	○	○	○	
5.12: Determination of Centroids of Volumes by Integration $\bar{x}V = \int \bar{x}_{el} dV \quad \bar{y}V = \int \bar{y}_{el} dV \quad \bar{z}V = \int \bar{z}_{el} dV \quad \bar{x}V = \int \bar{x}_{el} dV$	○	○	○	○	○	

Statics Survey Form B (Continued).

Engineering Subject: Statics						
Likert Scale (Score of Importance) Note: 1 → Totally Unimportant; 2 → Not So Important; 3 → Might Be Important; 4 → Important; 5 → Very Important						
Engineering Analytic Topics & Typical Formulas	**Likert Scale (Score of Importance from Least to Most)**					**Comment**
	1	**2**	**3**	**4**	**5**	
Chapter 7: Forces in Beams and Cables						
7.1: Introduction	○	○	○	○	○	
7.2: Internal Forces in Members	○	○	○	○	○	
Beams **7.3: Various Types of Loading and Support**	○	○	○	○	○	
7.4: Shear and Bending Moment in a Beam	○	○	○	○	○	
7.5: Shear and Bending-Moment Diagrams	○	○	○	○	○	
7.6: Relations among Load, Shear, and Bending Moment $\frac{dV}{dx} = -w \quad V_D - V_C = -\int_{x_C}^{x_D} w dx = -wx = = -$(Area under load curve between C an D) $\frac{dM}{dx} = V \quad M_D - M_C = \int_{x_C}^{x_D} V dx = -$(Area under shear curve between C an D)	○	○	○	○	○	
Cables **7.7: Cables with Concentrated Loads**	○	○	○	○	○	
7.8: Cables with Distributed Loads $T\cos\theta = T_O \quad T\sin\theta = W \quad T = \sqrt{T_O^2 + W^2} \quad \tan\theta = \frac{W}{T_O}$	○	○	○	○	○	
7.9: Parabolic Cable $y = \frac{wx^2}{2T_O}$	○	○	○	○	○	

Statics Survey Form B (Continued).

Engineering Subject: Statics						
Likert Scale (Score of Importance) Note: 1 → Totally Unimportant; 2 → Not So Important; 3 → Might Be Important; 4 → Important; 5 → Very Important						
Engineering Analytic Topics & Typical Formulas	**Likert Scale (Score of Importance from Least to Most)**					**Comment**
	1	**2**	**3**	**4**	**5**	
Chapter 7: Forces in Beams and Cables (Continued)						
7.10: Catenary $T=\sqrt{T_O^2+w^2s^2}$ $c=\frac{T_O}{w}$ $T_O=wc$ $W=ws$ $T=w\sqrt{c^2+s^2}$ $dx=ds\cos\theta=\frac{T_O}{T}ds=\frac{wcds}{w\sqrt{c^2+s^2}}$ $x=\int_O^S\frac{ds}{\sqrt{1+\frac{s^2}{c^2}}}=c\left[\sinh^{-1}\frac{s}{c}\right]_O^S=c\sinh^{-1}\frac{s}{c}$ $s=c\sinh\frac{x}{c}$ $y=c\cosh\frac{x}{c}$ $y^2-s^2=c^2$ $T_O=wc$ $W=ws$ $T=wy$ $h=y_A=c$	○	○	○	○	○	
Chapter 8: Friction						
8.8: Thrust Bearings. Disk Friction $\Delta M=r\Delta F=\frac{r\mu_k P\Delta A}{\pi\left(R_2^2-R_1^2\right)}$ $M=\frac{\mu_k P}{\pi\left(R_2^2-R_1^2\right)}\int_0^{2\pi}\int_{R_1}^{R_2}r^2drd\theta=\frac{\mu_k P}{\pi\left(R_2^2-R_1^2\right)}\int_0^{2\pi}\left[\frac{r^{2+1}}{2+1}\right]_{R_1}^{R_2}d\theta=\frac{\mu_k P}{\pi\left(R_2^2-R_1^2\right)}\int_0^{2\pi}\frac{1}{3}\left(R_2^3-R_1^3\right)d\theta$ Ring area: $M=\frac{2}{3}\mu_k P\frac{R_2^3-R_1^3}{R_2^2-R_1^2}$ Full circle: $M=\frac{2}{3}\mu_k PR$	○	○	○	○	○	
8.10: Belt Friction $\ln\frac{T_2}{T_1}=\mu_s\beta$ $\frac{T_2}{T_1}=e^{\mu_s\beta}$ (For other formulas, refer to pp. 451-452)	○	○	○	○	○	

Statics Survey Form B (Continued).

Engineering Subject: Statics						
Likert Scale (Score of Importance) Note: 1 → Totally Unimportant; 2 → Not So Important; 3 → Might Be Important; 4 → Important; 5 → Very Important						
Engineering Analytic Topics & Typical Formulas	**Likert Scale (Score of Importance from Least to Most)**					**Comment**
	1	**2**	**3**	**4**	**5**	
Chapter 9: Distributed Forces: Moments of Inertia						
9.1: Introduction	○	○	○	○	○	
Moments of Inertia of Areas **9.2: Second Moment, or Moment of Inertia, of an Area** $R=\int kydA=k\int ydA \quad M=\int ky^2dA=k\int y^2dA \quad R=\int \gamma ydA=\gamma\int ydA \quad M_x=\int y^2dA=\gamma\int y^2dA$	○	○	○	○	○	
9.3: Determination of the Moment of Inertia of an Area by Integration $I_x=\int y^2dA \quad I_y=\int x^2dA \quad dA=b\,dy \quad dI_x=y^2b\,dy$ $I_x=\int_O^h by^2dy=\frac{1}{3}BH^3 \quad dI_x=\frac{1}{3}y^3dx \quad dI_y=x^2dA=x^2ydx$	○	○	○	○	○	
9.4: Polar Moment of Inertia $J_O=\int r^2\ dA=\int(x^2+y^2)dA=\int y^2dA+\int x^2dA \quad J_O==I_x+I_y$	○	○	○	○	○	
9.5: Radius of Gyration of an Area $I_x=k_x^2A \ \rightarrow\ k_x=\sqrt{\frac{I_x}{A}} \quad I_y=k_y^2A \ \rightarrow\ k_y=\sqrt{\frac{I_y}{A}} \quad J_O=k_O^2A \ \rightarrow\ k_O=\sqrt{\frac{J_O}{A}}$	○	○	○	○	○	
9.6: Parallel-Axis Theorem $I=\int y^2dA$ $I=\int y^2dA=\int(y'+d)^2dA=\int y'^2\ dA+2d\int y'dA+d^2\int dA$ $I=\bar{I}+Ad^2 \quad k^2=\bar{k}^2+d^2 \quad J_O=\bar{J}_O+Ad^2 \quad or \quad k_O^2=\bar{k}_O^2+d^2$	○	○	○	○	○	
9.7: Moments of Inertia of Composite Areas (For formulas, refer to p. 485)	○	○	○	○	○	

Statics Survey Form B (Continued).

Engineering Subject: Statics						
Likert Scale (Score of Importance) Note: 1 → Totally Unimportant; 2 → Not So Important; 3 → Might Be Important; 4 → Important; 5 → Very Important						
Engineering Analytic Topics & Typical Formulas	**Likert Scale (Score of Importance from Least to Most)**					**Comment**
	1	**2**	**3**	**4**	**5**	
Chapter 9: Distributed Forces: Moments of Inertia (Continued)						
9.8: Product of Inertia $I_{xy} = \int xy\ dA = \int (x'+\bar{x})(y'+\bar{y})dA = \int x'y'\,dA + \bar{y}\int x'\,dA + \bar{x}\int y'\,dA + \bar{x}\bar{y}\int dA \quad I_{xy} == \bar{I}_{x'y'} + \bar{x}\bar{y}A$	○	○	○	○	○	
9.9: Principal Axes and Principal Moments of Inertia (For formulas, refer to pp. 498-500)	○	○	○	○	○	
9.10: Mohr's Circle for Moments and Products of Inertia	○	○	○	○	○	
Moments of Inertia of Masses **9.11: Moment of Inertia of a Mass** $I = \int r^2 dm \quad I = k^2 m \quad or \quad k = \sqrt{\frac{I}{m}} \quad I_x = \int (y^2 + z^2)dm \quad I_y = \int (z^2 + x^2)dm$ $I_z = \int (x^2 + y^2)dm$	○	○	○	○	○	
9.12: Parallel-Axis Theorem $x = x'+\bar{x} \quad y = y'+\bar{y} \quad z = z'+\bar{z} \quad I_x = \int (y^2 + z^2)dm$ $I_x = \bar{I}_{x'} + m(\bar{y}^2 + \bar{z}^2) = \int [(y'+\bar{y})^2 + (z'+\bar{z})^2]dm$ $= \int (y'^2 + z'^2)dm + 2\bar{y}\int y'\,dm + 2\bar{z}\int z'\,dm + (\bar{y}^2 + \bar{z}^2)\int dm$ $I_y = \bar{I}_{y'} + m(\bar{z}^2 + \bar{x}^2) \quad I_z = \bar{I}_{z'} + m(\bar{x}^2 + \bar{y}^2) \quad I = \bar{I} + md^2 \quad k^2 = \bar{k}^2 + d^2$	○	○	○	○	○	

Statics Survey Form B (Continued).

Engineering Subject: Statics						
Likert Scale (Score of Importance) Note: 1 → Totally Unimportant; 2 → Not So Important; 3 → Might Be Important; 4 → Important; 5 → Very Important						
Engineering Analytic Topics & Typical Formulas	**Likert Scale (Score of Importance from Least to Most)**					**Comment**
	1	**2**	**3**	**4**	**5**	
Chapter 9: Distributed Forces: Moments of Inertia (Continued)						
9.13: Moments of Inertia of Thin Plates $\left.\begin{array}{l} I_{AA',mass} = \int r^2 dm \\ dm = \rho t \; dA \end{array}\right\} \quad I_{AA',mass} = \rho t \int r^2 dA$ $I_{AA',mass} = \rho t I_{AA',area} \quad I_{BB',mass} = \rho t I_{BB',area} \quad I_{CC',mass} = \rho t J_{C,area} \quad I_{CC'} = I_{AA'} + I_{BB'}$ Rectangular Plate $I_{AA',mass} = \rho t I_{AA',area} = \rho t\left(\frac{1}{12}a^3 b\right) \quad I_{BB',mass} = \rho t I_{BB',area} = \rho t\left(\frac{1}{12}ab^3\right)$ $I_{AA'} = \frac{1}{12}ma^2 \quad I_{BB'} = \frac{1}{12}mb^2 \quad I_{CC'} = I_{AA'} + I_{BB'} = \frac{1}{12}m\left(a^2 + b^2\right)$ Circular Plate $I_{AA',mass} = \rho t I_{AA',area} = \rho t\left(\frac{1}{4}\pi r^4\right) \quad I_{AA'} = I_{BB'} = \frac{1}{4}mr^2 \quad I_{CC'} = I_{AA'} + I_{BB'} = \frac{1}{12}mr^2$	○	○	○	○	○	
9.14: Determination of the Moment of Inertia of a Three-Dimensional Body by Integration (For formulas, refer to p. 517).	○	○	○	○	○	
9.15: Moments of Inertia of Composite Bodies	○	○	○	○	○	

Statics Survey Form B (Continued).

Engineering Subject: Statics						
Likert Scale (Score of Importance) Note: 1 → Totally Unimportant; 2 → Not So Important; 3 → Might Be Important; 4 → Important; 5 → Very Important						
Engineering Analytic Topics & Typical Formulas	**Likert Scale (Score of Importance from Least to Most)**					**Comment**
	1	**2**	**3**	**4**	**5**	
Chapter 9: Distributed Forces: Moments of Inertia (Continued)						
9.16: Moment of Inertia of a Body with Respect to an Arbitrary Axis through *O*. Mass Products of Inertia $I_{OL} = \int p^2 dm = \int \left\lvert \vec{\lambda} \times \vec{r} \right\rvert^2 dm = \int \left[(\lambda_x y - \lambda_y x)^2 + (\lambda_y z - \lambda_z y)^2 + (\lambda_z x - \lambda_x z)^2 \right]$ $= \lambda_x^2 \int (y^2 + z^2) dm + \lambda_y^2 \int (z^2 + x^2) dm + \lambda_z^2 \int (x^2 + y^2) dm -$ $2\lambda_x \lambda_y \int xy\ dm - 2\lambda_y \lambda_z \int yz\ dm - 2\lambda_z \lambda_x \int zx\ dm$ $I_{xy} = \int xy\ dm \quad I_{yz} = \int yz\ dm \quad I_{zx} = \int zx\ dm$ $I_{OL} = I_x \lambda_x^2 + I_y \lambda_y^2 + I_z \lambda_z^2 - 2I_{xy} \lambda_x \lambda_y - 2I_{yz} \lambda_y \lambda_{yz} - 2I_{zx} \lambda_z \lambda_x$ $I_{xy} = \bar{I}_{x'y'} + m\overline{xy} \quad I_{yz} = \bar{I}_{y'z'} + m\overline{yz} \quad I_{zx} = \bar{I}_{z'x'} + m\overline{zx}$	○	○	○	○	○	
9.17: Ellipsoid of Inertia. Principal Axes of Inertia $(OQ)\lambda_x = x \quad (OQ)\lambda_y = y \quad (OQ)\lambda_z = z \quad I_x x^2 + I_y y^2 + I_z z^2 - 2I_{xy} xy - 2I_{yz} yz - 2I_{zx} zx = 1$ $I_{x'} x'^2 + I_{y'} y'^2 + I_{z'} z'^2 = 1 \quad I_{OL} = I_{x'} \lambda_{x'}^2 + I_{y'} \lambda_{y'}^2 + I_{z'} \lambda_{z'}^2$	○	○	○	○	○	

Statics Survey Form B (Continued).

Engineering Subject: Statics						
Likert Scale (Score of Importance) Note: 1 → Totally Unimportant; 2 → Not So Important; 3 → Might Be Important; 4 → Important; 5 → Very Important						
Engineering Analytic Topics & Typical Formulas	**Likert Scale (Score of Importance from Least to Most)**					**Comment**
	1	**2**	**3**	**4**	**5**	
Chapter 9: Distributed Forces: Moments of Inertia (Continued)						
9.18: Determination of the Principal Axes and Principal Moments of Inertia of a Body of Arbitrary Shape $\left.\begin{array}{l}\nabla f = (2K)\vec{r} \\ K = \text{constant} \\ \vec{r} = x\hat{i} + y\hat{j} + z\hat{k}\end{array}\right\} \rightarrow \nabla f = \frac{\partial f}{\partial x}\hat{i} + \frac{\partial f}{\partial y}\hat{j} + \frac{\partial f}{\partial z}\hat{k}$ $f(x,y,z) = I_x x^2 + I_y y^2 + I_z z^2 - 2I_{xy}xy - 2I_{yz}yz - 2I_{zx}zx - 1$ … $\begin{vmatrix} I_x - K & -I_{xy} & -I_{zx} \\ -I_{xy} & I_y - K & -I_{yz} \\ -I_{zx} & -I_{yz} & I_z - K \end{vmatrix} = 0$ (More formulas on p.p. 534-535)	○	○	○	○	○	

Statics Survey Form B (Continued).

Engineering Subject: Statics						
Likert Scale (Score of Importance) Note: 1 → Totally Unimportant; 2 → Not So Important; 3 → Might Be Important; 4 → Important; 5 → Very Important						
Engineering Analytic Topics & Typical Formulas	**Likert Scale (Score of Importance from Least to Most)**					**Comment**
	1	**2**	**3**	**4**	**5**	
Chapter 10: Method of Virtual Work						
10.1: Introduction	○	○	○	○	○	
10.2: Work of a Force $dU = \vec{F} \bullet d\vec{x} \quad dU = F\, ds \cos\alpha \quad dU = M\ d\theta$	○	○	○	○	○	
10.3: Principle of Virtual Work $\delta U = \vec{F}_1 \bullet \delta\vec{r} + \vec{F}_2 \bullet \delta\vec{r} + \ldots + \vec{F}_n \bullet \delta\vec{r} = \left(\vec{F}_1 + \vec{F}_2 + \ldots + \vec{F}_n\right) \bullet \delta\vec{r} \quad \rightarrow \quad \delta U = \vec{R} \bullet \delta\vec{r}$	○	○	○	○	○	
10.4: Applications of the Principle of Virtual Work $x_B = 2\ell \sin\theta \quad y_C = \ell \cos\theta \quad \delta x_B = 2\ell \cos\theta\delta\theta \quad \delta y_C = -\ell \sin\theta\delta\theta$ $\delta U = \delta U_Q + \delta U_P = -Q\delta x_B - P\delta y_C = -2Q\ell \cos\theta\ \delta\theta + P\ell \sin\theta\ \delta\theta$ $\delta U = 0 \quad \rightarrow \quad 2Q\ell \cos\theta\ \delta\theta = P\ell \sin\theta\ \delta\theta \quad \rightarrow \quad Q = \frac{1}{2} P \tan\theta \quad B_x = -\frac{1}{2} P \tan\theta$	○	○	○	○	○	
10.5: Real Machines. Mechanical Efficiency $\delta U = -Q\delta x_B - P\delta y_C - F\delta x_B = -2Q\ell \cos\theta\ \delta\theta + P\ell \sin\theta\ \delta\theta - \mu P\ell \cos\theta\ \delta\theta$ $\delta U = 0 \quad \rightarrow \quad 2Q\ell \cos\theta\ \delta\theta = P\ell \sin\theta\ \delta\theta - \mu P\ell \cos\theta\ \delta\theta \quad \rightarrow$ $\eta = \frac{\text{output work}}{\text{input work}} = \frac{2Q\ell \cos\theta\ \delta\theta}{P\ell \sin\theta\ \delta\theta}$ $\eta = \frac{2\left(\frac{1}{2} P(\tan\theta - \mu)\right)\ell \cos\theta\ \delta\theta}{P\ell \sin\theta\ \delta\theta} = \frac{P(\tan\theta - \mu)\ell \cos\theta\ \delta\theta}{P\ell \sin\theta\ \delta\theta} = 1 - \mu \cot\theta$	○	○	○	○	○	

Statics Survey Form B (Continued).

Engineering Subject: Statics						
Likert Scale (Score of Importance) Note: 1 → Totally Unimportant; 2 → Not So Important; 3 → Might Be Important; 4 → Important; 5 → Very Important						
Engineering Analytic Topics & Typical Formulas	**Likert Scale (Score of Importance from Least to Most)**					**Comment**
	1	**2**	**3**	**4**	**5**	
Chapter 10: Method of Virtual Work (Continued)						
10.6: Work of a Force during a Finite Displacement $dU = \vec{F} \bullet d\vec{r} \rightarrow U_{1\to 2} = \int_{A_1}^{A_2} \vec{F} \bullet d\vec{r} \quad dU = F\ ds \cos\alpha \rightarrow U_{1\to 2} = \int_{S_1}^{S_2} (F \cos\alpha) ds$ $dU = M d\theta \rightarrow U_{1\to 2} = \int_{\theta_1}^{\theta_2} M\ d\theta \quad U_{1\to 2} = M(\theta_2 - \theta_1)$ Work of a weight $dU = -W\ dy \rightarrow U_{1\to 2} = -\int_{y_1}^{y_2} W\ dy \quad U_{1\to 2} = -W(y_2 - y_1) = -W\ \Delta y$ Work of the force exerted by a spring $F = kx \rightarrow dU = -F\ dx = -kx\ dx$ $U_{1\to 2} = -\int_{x_1}^{x_2} kx\ dx = \frac{1}{2}kx_1^2 - \frac{1}{2}kx_2^2 \quad U_{1\to 2} = -\frac{1}{2}(F_1 + F_2)\Delta x$	○	○	○	○	○	
10.7: Potential Energy $U_{1\to 2} = (V_g)_1 - (V_g)_2 \leftarrow V_g = Wy \quad U_{1\to 2} = (V_e)_1 - (V_e)_2 \leftarrow V_e = \frac{1}{2}kx^2$ $dU = -dV \quad U_{1\to 2} = V_1 - V_2$	○	○	○	○	○	

Statics Survey Form B (Continued).

Engineering Subject: Statics						
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Engineering Analytic Topics & Typical Formulas	**Likert Scale (Score of Importance from Least to Most)**					**Comment**
	1	**2**	**3**	**4**	**5**	
Chapter 10: Method of Virtual Work (Continued)						
10.8: Potential Energy and Equilibrium $\frac{dV}{d\theta}=0 \quad V_e=\frac{1}{2}kx_B^2 \quad V_g=Wy_C \quad x_B=2\ell\sin\theta \quad y_C=\ell\cos\theta$ $V_e=\frac{1}{2}k(2\ell\sin\theta)^2 \quad V_g=W(\ell\cos\theta) \quad V=V_e+V_g=2k\ell^2\sin^2\theta+W\ell\cos\theta$ $\frac{dV}{d\theta}=4k\ell^2\sin\theta\cos\theta-W\ell\sin\theta=0 \quad \frac{dV}{d\theta}=\ell\sin\theta(4k\ell\cos\theta-W)=0$	○	○	○	○	○	
10.9: Stability of Equilibrium $\frac{dV}{d\theta}=0 \quad \frac{d^2V}{d\theta^2}>0:\text{stable equilibrium} \quad \frac{dV}{d\theta}=0 \quad \frac{d^2V}{d\theta^2}<0:\text{unstable equilibrium}$ $\frac{\partial V}{\partial\theta_1}=\frac{\partial V}{\partial\theta_2}=0 \quad \left(\frac{\partial^2V}{\partial\theta_1\partial\theta_2}\right)^2-\frac{\partial^2V}{\partial\theta_1^2}\frac{\partial^2V}{\partial\theta_2^2}<0 \quad \frac{\partial^2V}{\partial\theta_1^2}>0 \text{ or } \frac{\partial^2V}{\partial\theta_2^2}>0$	○	○	○	○	○	
TE END						

Part Three
Findings from the Research Project

List 1A. Pre-Calculus Based Statics Topics That Possibly Could Be Taught at 9th Grade

Chapter/Section	Page Numbers	Number of Pages
Chapter 1: Introduction (pp. 1-13 → 13 pages sub-total. 6 sections out of 6)		
1.1: What Is Mechanics?	1-13	13
1.2: Fundamental Concepts and Principles		
1.3: Systems of Units		
1.4: Conversion from One System of Units to Another		
1.5: Method of Problem Solution		
1.6: Numerical Accuracy		
Chapter 2: Statics of Particles (pp. 15-63 → 49 pages sub-total. 15 sections out of 15)		
2.1: Introduction	15-63	49
2.2: Force on a Particle. Resultant of Two Forces		
2.3: Vectors		
2.4: Addition of Vectors		
2.5: Resultant of Several Concurrent Forces		
2.6: Resolution of a Force into Components		
2.7: Rectangular Components of a Force. Unit Vector		
2.8: Addition of Forces by Summing *x* and *y* Components		
2.9: Equilibrium of a Particle		
2.10: Newton's First Law of Motion		
2.11: Problems Involving the Equilibrium of a Particle. Free-Body Diagrams		
2.12: Rectangular Components of a Force in Space		
2.13: Force Defined by Its Magnitude and Two Points on Its Line of Action		
2.14: Addition of Concurrent Forces in Space		
2.15: Equilibrium of a Particle in Space		
Chapter 3: Rigid Bodies - Equivalent Systems of Forces (pp. 74-145 → 72 pages sub-total. 21 sections out of 21)		
3.1: Introduction	74-145	72
3.2: External and Internal Forces		
3.3: Principle of Transmissibility. Equivalent Forces		
3.4: Vector Product of Two Vectors		
3.5: Vector Products Expressed in Terms of Rectangular Components		
3.6: Moment of a Force about a Point		
3.7: Varignon's Theorem		
3.8: Rectangular Components of the Moment of a Force		
3.9: Scalar Product of Two Vectors		
3.10: Mixed Triple Product of Three Vectors		

List 1A. (Continued)

Chapter/Section	Page Numbers	Number of Pages
Chapter 3: Rigid Bodies - Equivalent Systems of Forces (Continued)		
3.11: Moment of a Force about a Given Axis	↑	↑
3.12: Moment of a Couple		
3.13: Equivalent Couples		
3.14: Addition of Couples		
3.15: Couples Can Be Represented by Vectors		
3.16: Resolution of a Given Force Into a Force at *O* and a Couple		
3.17: Reduction of a System of Forces to One Force and One Couple		
3.18: Equivalent Systems of Forces		
3.19: Equipollent Systems of Vectors		
3.20: Further Reduction of a System of Forces		
3.21: Reduction of a System of Forces to a Wrench		
Chapter 4: Equilibrium of Rigid Bodies (pp. 158-210 → 53 pages sub-total. 9 sections out of 9)		
4.1: Introduction	158-210	53
4.2: Free-Body Diagram		
4.3: Reactions at Supports and Connections for a Two-Dimensional Structure		
4.4: Equilibrium of a Rigid Body in Two Dimensions		
4.5: Statically Indeterminate Reactions. Partial Constraints		
4.6: Equilibrium of a Two-Force Body		
4.7: Equilibrium of a Three-Force Body		
4.8: Equilibrium of a Rigid Body in Three Dimensions		
4.9: Reactions at Supports and Connections for a Three-Dimensional Structure		
Chapter 5: Distributed Forces: Centroids & Centers of Gravity (pp. 219-273 → 55 pages sub-total. 0 sections out of 11)		
Chapter 6: Analysis of Structures (pp. 284-342 → 59 pages sub-total. 12 sections out of 12)		
6.1: Introduction	284-342	59
6.2: Definition of a Truss		
6.3: Simple Trusses		
6.4: Analysis of Trusses by the Method of Joints		
6.5: Joints under Special Loading Conditions		
6.6: Space Trusses		
6.7: Analysis of Trusses by the Method of Sections		
6.8: Trusses Made of Several Simple Trusses		
6.9: Structures Containing Multiforce Members		

List 1A. (Continued)

Chapter/Section	Page Numbers	Number of Pages
Chapter 6: Analysis of Structures (Continued)		
6.10: Analysis of a Frame	↑	↑
6.11: Frames Which Cease to Be Rigid When Detached from Their Supports		
6.12: Machines		
Chapter 7: Forces in Beams and Cables (pp. 353-401 → 49 pages sub-total. 0 sections out of 10)		
Chapter 8: Friction (pp. 411-460 → 50 pages sub-total. 8 sections out of 10)		
8.1: Introduction	411-441	31
8.2: The Laws of Dry Friction. Coefficients of Friction		
8.3: Angles of Friction		
8.4: Problems Involving Dry Friction		
8.5: Wedges		
8.6: Square-Threaded Screws		
8.7: Journal Bearings. Axle Friction		
8.9: Wheel Friction. Rolling Resistance	443-450	8
Chapter 9: Distributed Forces: Moments of Inertia (pp. 471-544 → 74 pages sub-total. 0 sections out of 18)		
Chapter 10: Method of Virtual Work (pp. 557-591→ 35 pages sub-total. 0 sections out of 9)		

List 1A. (Continued)

Summary	
Total Number of Pages Covered by Text (Excluding "Review and Summary for Chapters," "Review Problems" and "Computer Problems Sections)	509
Total Numbers of Sections Covered Under All Chapters	71 out of 121
Percentage of Pre-Calculus Sections $\%_{\text{Pre-Calculus}} = \left(\frac{\text{Number of Pre-Calculus Sections}}{\text{Total Number of Sections}}\right)(100\%) = \left(\frac{71}{121}\right)(100\%) = 58.7\%$	
Total Numbers of Chapters Covered	6 out of 10
Percentage of Chapters with Pre-Calculus Sections $\%_{\text{Pre-Calculus}} = \left(\frac{\text{Number of Chapters with Pre-Calculus Sections}}{\text{Total Number of Chapters}}\right)(100\%) = \left(\frac{6}{10}\right)(100\%) = 60.0\%$	
Total Number of Pages Covered by Pre-Calculus Portion	285
Percentage of Pre-Calculus Volume $\%_{\text{Pre-Calculus}} = \left(\frac{\text{Number of Pre-Calculus Pages}}{\text{Total Number of Pages}}\right)(100\%) = \left(\frac{285}{509}\right)(100\%) = 56.0\%$	

List 1B. Pre-Requisite Mathematics and Science Topics to Be Reviewed Before Teaching the Pre-Calculus Portion of Statics Topics to 9th Grade Students

Math & Science Pre-requisite Topics & Completion Grade (Georgia Performance Standard Code) [Pre-requisite Math Skills/Science Principles] (GPS Code) → Grade (Table No.)	
Math	**Physics**
1. [areas of geometric shapes: circle, triangle, etc.] (M5M1) → 5th and (2B) (M6M2) → 6th (2C) 2. [coordinate system] (M4G3) → 4th (2B) 3. [cross product] → To be taught as a special math topic 4. [dot product] → To be taught as a special math topic 5. [four operations] (M1N3) → 1st (2A) + (M2N3) → 2nd (1A), or (M7N1) → 7th (2A) 6. [geometry: point, axis/line, 3D body] (M6G1) (M6G2) (M6M3) → 6th (2B) 7. [linear algebra](MA2A6) (MA2A7) (MA2A8) (MA2A9) → 10th (2G) → To be taught as a special math topic 8. [measurement: time] (M2M2) → 2nd (2C) 9. [Parallelogram Law for the Addition of Force/Vector Graphics] (MA3A10) → 11th (2H) → To be taught as a special math topic 10. [percent] (M5N5) → 5th (2A) 11. [problem-solving] (M3N5) → 3rd (2A) 12. [sigma notation] (M6N1) → 6th (1A) or (MA1A3) → 9th (2E) → To be taught as a special math topic 13. [square root] (M8N1) → 8th (2A) 14. [surface] (M6M4) → 6th (2B) **15.** [trigonometric functions] (MA2G2) → 10th (2F) → To be taught as a special math topic [unit conversion] (M6M1) → 6th (2C) 16. [vector graphics] (MA3A10) → 9th (2H) → To be taught as a special math topic	1. [acceleration] (S8P3) → 8th (3C) 2. [force] (S4P3) → 4th (3A) or (S8P3) → 8th (3C) 3. [lever] (S4P3) → 4th (3A) 4. [motion] (SKP2) → K (3A) 5. [Newton's 1st, 2nd and 3rd Laws] (SP1) → 9th (3C) 6. [Newton's Law of Gravitation] (S8P5) → 8th (3C) 7. [scientific inquiry] (S7CS9) →7th (3B)

List 2A. Calculus Based Statics Topics for Post-Secondary Engineering Education

Chapter/Section	Page Nos.	Chapter/Section	Page Nos.
Chapter 5: Distributed Forces: Centroids & Centers of Gravity		**Chapter 7: Forces in Beams and Cables**	
5.1: Introduction	219-273	7.1: Introduction	354-401
5.2: Center of Gravity of a Two-Dimensional Body		7.2: Internal Forces in Members	
5.3: Centroids of Areas and Lines		7.3: Various Types of Loading and Support	
5.4: First Moments of Areas and Lines		7.4: Shear and Bending Moment in a Beam	
5.5: Composite Plates and Wires		7.5: Shear and Bending-Moment Diagrams	
5.6: Determination of Centroids by Integration		7.6: Relations among Load, Shear, and Bending Moment	
5.7: Theorems of Pappus-Guldinus		7.7: Cables with Concentrated Loads	
5.8: Distributed Loads on Beams		7.8: Cables with Distributed Loads	
5.9: Forces on Submerged Surfaces		7.9: Parabolic Cable	
5.10: Center of Gravity of a Three- Dimensional Body. Centroid of a Volume		7.10: Catenary	
		Chapter 8: Friction	
5.11: Composite Bodies		8.8: Thrust Bearings. Disk Friction	442-443
5.12: Determination of Centroids of Volumes by Integration		8.10: Belt Friction	450-460
Chapter 9: Distributed Forces: Moments of Inertia			
9.1: Introduction	472-544	9.10: Mohr's Circle for Moments and Products of Inertia	←
9.2: Second Moment, or Moment of Inertia, of an Area		9.11: Moment of Inertia of a Mass	
9.3: Determination of the Moment of Inertia of an Area by Integration		9.12: Parallel-Axis Theorem	
9.4: Polar Moment of Inertia		9.13: Moments of Inertia of Thin Plates	
9.5: Radius of Gyration of an Area		9.14: Determination of the Moment of Inertia of a Three-Dimensional Body by Integration	
9.6: Parallel-Axis Theorem		9.15: Moments of Inertia of Composite Bodies	
9.7: Moments of Inertia of Composite Areas		9.16: Moment of Inertia of a Body with Respect to an Arbitrary Axis through *O*. Mass Products of Inertia	
9.8: Product of Inertia		9.17: Ellipsoid of Inertia. Principal Axes of Inertia	
9.9: Principal Axes and Principal Moments of Inertia		9.18: Determination of the Principal Axes and Principal Moments of Inertia of a Body of Arbitrary Shape	
Chapter 10: Method of Virtual Work			
10.1: Introduction	557-591	10.6: Work of a Force during a Finite Displacement	←
10.2: Work of a Force		10.7: Potential Energy	
10.3: Principle of Virtual Work		10.8: Potential Energy and Equilibrium	
10.4: Applications of the Principle of Virtual Work		10.9: Stability of Equilibrium	
10.5: Real Machines. Mechanical Efficiency			

List 2B. Pre-Requisite Math and Science Topics to Be Reviewed Before Teaching the Calculus Portion of Statics Topics

Math & Science Pre-requisite Topics & Completion Grade (Georgia Performance Standard Code) [Pre-requisite Math Skills/Science Principles] (GPS Code) → Grade (Table No.)	
Math	**Physics/Chemistry**
1. [areas of geometric shapes: circle, triangle, etc.] (M3M3) (M3M4) → 3rd (2B), (M5M1) → 5th and (2B) (M6M2) → 6th (2C) 2. [coordinate system] (M4G3) → 4th (2B) 3. [cross product] → To be taught as a special math topic 4. [differentiation] → 12th (to be taught) 5. [dot product] → To be taught as a special math topic 6. [four operations] (M1N3) → 1st (2A) + (M2N3) → 2nd (1A), or (M7N1) → 7th (2A) 7. [geometry: point, axis/line, 3D body] (M6G1) (M6G2) (M6M3) → 6th (2B) 8. [geometric shapes: ellipse] (MA2G4) → 10th (2F) → To be taught as a special math topic 9. [gradient: "del"] → 12th (to be taught) 10. [integration] → 12th (To be taught) 11. [integration: area of surface of revolution, curve, volume of body of revolution] → 12th (To be taught) 12. [linear algebra](MA2A6) (MA2A7) (MA2A8) (MA2A9) → 10th (2G) → To be taught as a special math topic 13. [logarithmic functions] (MA2A4) → 10th (2E) → To be taught as a special math topic 14. [measurement: area, weight, thickness] (M6M1) (M6M2) → 6th (2C) 15. [measurement: time] (M2M2) → 2nd (2C) 16. [Parallelogram Law for the Addition of Force/Vector Graphics] (MA3A10) → 11th (2H) → To be taught as special topic 17. [partial differentiation] → 12th (to be taught) 18. [percent] (M5N5) → 5th (2A) 19. [problem-solving] (M3N5) → 3rd (2A) 20. [sigma notation] (M6N1) → 6th (1A) or (MA1A3) → 9th (2E) → To be taught as a special math topic 21. [special two-dimensional figures: parabolic spandrel, general spandrel] → To be taught as a special math topic 22. [square root] (M8N1) → 8th (2A) 23. [surface] (M6M4) → 6th (2B) 24. [three-dimensional bodies: circular cone, sphere] (M2G2) → 2nd (2B) 25. [three-dimensional bodies: slender rod, circular cylinder, cone] (M6M3) → 6th (2B) 26. [three-dimensional bodies: thin rectangular plate, rectangular prism] (M5M4) → 5th (2B) 27. [trigonometric functions] (MA2G2) → 10th (2F) → To be taught as a special math topic 28. [two-dimensional figures: circle, arc, triangle, ellipse, parabolic] (M1G1) (M1G2) → 1st (1B) + (MA2G4) → 10th (2F) → To be taught as a special math topic **29.** [unit conversion] (M6M1) → 6th (2C) 30. [vector graphics] (MA3A10) → 9th (2H) → To be taught as a special math topic 31. [volume: sphere, cone, pyramid] (M5M4) → 5th (1B) (M6M3) → 6th (2B) 32. (MA1G5) → 9th (2F) 33. [volume: ellipsoid, paraboloid] → To be taught as a special math topic	1. [acceleration] (S8P3) → 8th (3C) 2. [force] (S4P3) → 4th (3A) or (S8P3) → 8th (3C) 3. [lever] (S4P3) → 4th (3A) 4. [motion] (SKP2) → K (3A) 5. [Newton's 1st, 2nd and 3rd Laws] (SP1) → 9th (3C) 6. [Newton's Law of Gravitation] (S8P5) → 8th (3C) 7. [potential energy] (SP3) → 9th (3C) 8. [power] (SP3) → 9th (3C) 9. [scientific inquiry] (S7CS9) →7th (3B) 10. [work] (S8P3) → 8th (3C)