Table 8

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** $\vec{a}=\frac{\vec{F}}{m}\Rightarrow\vec{F}=m\vec{a}\quad\vec{F}_{AB}=-\vec{F}_{BA}\quad\vec{F}=G\frac{m_1m_2}{r^2}$	[coordinate system] (M4G3) → 4^{th} (2B) [measurement: time] (M2M2) → 2^{nd} (2C) [Parallelogram Law for the Addition of Force/Vector Graphics] (MA3A10) → 11^{th} (2H) → To be taught as a special math topic	[force] (S4P3) → 4^{th} (3A) or (S8P3) → 8^{th} (3C) [Newton's 1^{st}, 2^{nd} and 3^{rd} Laws] (SP1) → 9^{th} (3C) [acceleration] (S8P3) → 8th (3C) [Newton's Law of Gravitation] (S8P5) → 8^{th} (3C) [scientific inquiry] (S7CS9) → 7^{th} (3B)	9^{th}	9^{th}
1.3: Systems of Units **1.4: Conversion from One System of Units to Another**	[unit conversion] (M6M1) → 6^{th} (2C)	N/A	6^{th}	
1.5: Method of Problem Solution	[problem-solving] (M3N5) → 3^{rd} (2A)	N/A	3^{rd}	
1.6: Numerical Accuracy	[percent] (M5N5) → 5^{th} (2A)	N/A	5^{th}	
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) → 1^{st} (2A) + (M2N3) → 2^{nd} (1A), or (M7N1) → 7^{th} (2A) [coordinate system] (M4G3) → 4^{th} (2B)	[force] (S4P3) → 4^{th} (3A)	4^{th}	9^{th}
2.3: Vectors **2.4: Addition of Vectors** **2.5: Resultant of Several Concurrent Forces**	[vector graphics] (MA3A10) → 9^{th} (2H) → To be taught as a special math topic	[force] (S4P3) → 4^{th} (3A) or (S8P3) → 8^{th} (3C)	9^{th}	
2.6: Resolution of a Force into Components **2.7: Rectangular Components of a Force. Unit Vectors**	[vector graphics] (MA3A10) → 9^{th} (2H) [trigonometric functions] (MA2G2) → 9^{th} (2F)	[force] (S4P3) → 4^{th} (3A) or (S8P3) → 8^{th} (3C)	9^{th}	
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) → 1^{st} (2A) + (M2N3) → 2^{nd} (2A), 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)	8^{th}	
2.9: Equilibrium of a Particle $R=\sum F=F_1+F_2+...=0\quad\Rightarrow\quad R_x=\sum F_x=0\quad R_y=\sum F_y=0$ $R_z=\sum F_z=0$	[summation] (MA1A3) → 9^{th} (2E) [four operations] (M1N3) → 1^{st} (2A) + (M2N3) → 2^{nd} (1A), or (M7N1) → 7^{th} (2A)	[force] (S4P3) → 4^{th} (2A) or (S8P3) → 8^{th} (2C)	9^{th}	

Table 8 (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) → 1st (2A) + (M2N3) → 2nd (1A), or (M7N1) → 7th (2A)	[Newton's 1st, 2nd and 3rd Laws] (SP1) → 9th (3C) [acceleration] (S8P3) → 8th (3C)	9th	9th
<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) → 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)	9th	

Table 8 (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 (2A) 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 (2A) or (S8P3) → 8th (3C) [Newton's 1st, 2nd and 3rd Laws] (SP1) → 9th (3C)	9th	
2.15: Equilibrium of a Particle in Space $R = \sum F = F_1 + F_2 + ... = 0 \quad \rightarrow \quad R_x = \sum F_x = 0 \quad R_y = \sum F_y = 0 \quad R_z = \sum F_z = 0$ $\begin{bmatrix} a & b & c \\ d & e & f \\ g & h & i \end{bmatrix} \times \begin{bmatrix} x \\ y \\ z \end{bmatrix} = \begin{bmatrix} ax+by+cz \\ dx+ey+fz \\ gx+hy+iz \end{bmatrix} \quad \begin{bmatrix} a & b & c \\ d & e & f \\ g & h & i \end{bmatrix} \times \begin{bmatrix} F_1 \\ F_2 \\ F_3 \end{bmatrix} = \begin{bmatrix} 0 \\ 0 \\ 0 \end{bmatrix}$ $R_x = \sum F_x = 0 \quad aF_1 + bF_2 + cF_3 = 0$ $R_y = \sum F_y = 0 \quad dF_1 + eF_2 + fF_3 = 0$ $R_z = \sum F_z = 0 \quad gF_1 + hF_2 + iF_3 = 0$ $\begin{bmatrix} a & b & c \\ d & e & f \\ g & h & i \end{bmatrix} \times \begin{bmatrix} F_1 \\ F_2 \\ F_3 \end{bmatrix} = \begin{bmatrix} aF_1+bF_2+cF_3 \\ dF_1+eF_2+fF_3 \\ gF_1+hF_2+iF_3 \end{bmatrix}$	[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 (2A) or (S8P3) → 8th (3C) [Newton's 1st, 2nd and 3rd Laws] (SP1) → 9th (3C)	9th	

Table 8 (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 $\vec{V}=\vec{P}\times\vec{Q}\quad V=PQ\sin\theta\quad \vec{V}\perp\vec{P}\quad \vec{V}\perp\vec{Q}\quad \vec{V}\perp Plane_{\vec{P},\vec{Q}}$ $\vec{P}\times(\vec{Q}_1+\vec{Q}_2)=\vec{P}\times\vec{Q}_1+\vec{P}\times Q_2\quad (\vec{P}\times\vec{Q})\times\vec{S}\neq\vec{P}\times(\vec{Q}\times\vec{S})$ $\vec{V}=\vec{Q}\times\vec{P}=-(\vec{P}\times\vec{Q})\quad \vec{Q}\times\vec{P}\neq\vec{P}\times\vec{Q}\quad \vec{P}\times\vec{Q}=-\vec{V}$ $\vec{P}\times(\vec{Q}_1+Q_2)=\vec{P}\times\vec{Q}_1+\vec{P}\times Q_2\quad \vec{Q}\times\vec{P}\neq\vec{P}\times\vec{Q}$ $\vec{V}=\vec{Q}\times\vec{P}=-(\vec{P}\times\vec{Q})\quad \vec{P}\times\vec{Q}=-\vec{V}\quad \vec{V}=\vec{P}\times\vec{Q}\quad (\vec{P}\times\vec{Q})\times\vec{S}\neq\vec{P}\times(\vec{Q}\times\vec{S})$	[trigonometric functions] (MA2G2) → 10th (2F) → To be taught as a special math topic [special math: vector product or cross product] → To be taught as a special math topic	[force] (S4P3) → 4th (3A) [motion] (SKP2) → K (3A)	9th	
3.5: Vector Products Expressed in Terms of Rectangular Components $\hat{i}\times\hat{i}=\hat{j}\times\hat{j}=\hat{k}\times\hat{k}=0\quad \hat{i}\times\hat{j}=\hat{k}\quad \hat{j}\times\hat{k}=\hat{i}\quad \hat{k}\times\hat{i}=\hat{j}$ $\hat{i}\times\hat{k}=-\hat{j}\quad \hat{j}\times\hat{i}=-\hat{k}\quad \hat{k}\times\hat{j}=-\hat{i}$ $\vec{P}=P_x\hat{i}+P_y\hat{j}+P_z\hat{k}\quad \vec{Q}=Q_x\hat{i}+Q_y\hat{j}+Q_z\hat{k}$ $\vec{V}=\vec{P}\times\vec{Q}=\begin{vmatrix}\hat{i} & \hat{j} & \hat{k}\\ P_x & P_y & P_z\\ Q_x & Q_y & Q_z\end{vmatrix}=V_x\hat{i}+V_y\hat{j}+V_z\hat{k}$ $V_x=P_yQ_z-P_zQ_y\quad V_y=-(P_xQ_z-P_zQ_x)=P_zQ_x-P_xQ_z$ $V_z=P_xQ_y-P_yQ_x$	[trigonometric functions] (MA2G2) → 10th (2F) [special math: vector product or cross product] → To be taught as a special math topic [special math: scalar product] → To be taught as a special math topic	[force] (S4P3) → 4th (3A)	9th	

Table 8 (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) → 1st (1A) + (M2N3) → 2nd (2A) [geometry: point, axis/line, 3D body] (M6G1) (M6G2) (M6M3) → 6th (2B) [special math: vector product or cross product] → To be taught as a special math topic [special math: scalar product] → To be taught as a special math topic [linear algebra](MA2A6) (MA2A7) (MA2A8) (MA2A9) → 10th (2G) → To be taught as a special math topic	[force] (S4P3) → 4th (3A)	9th	9th
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) → 1st (1A) + (M2N3) → 2nd (2A) [special math: vector product or cross product] → To be taught as a special math topic [special math: scalar product] → To be taught as a special math topic	[force] (S4P3) → 4th (3A)	9th	
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) → 1st (1A) + (M2N3) → 2nd (2A) [special math: vector product or cross product] → To be taught as a special math topic	[force] (S4P3) → 4th (3A)	9th	

Table 8 (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 $\vec{P}\bullet\vec{Q}=PQ\cos\theta=P_xQ_x+P_yQ_y+P_zQ_z \quad \theta=\angle_{\vec{P}\to\vec{Q}}$ $\vec{P}\bullet\vec{Q}=\vec{Q}\bullet\vec{P} \quad \vec{P}\bullet\left(\vec{Q}_1+\vec{Q}_2\right)=\vec{P}\bullet\vec{Q}_1+\vec{P}\bullet\vec{Q}_2$ $P_{OL}=\vec{P}\bullet\hat{\lambda}=P_x\cos\theta_x+P_y\cos\theta_y+P_z\cos\theta_z$ (More formulas on p. pp. 94-95)	[four operations] (M1N3) → 1^{st} (1A) + (M2N3) → 2^{nd} (2A) [special math: scalar product] → To be taught as a special math topic	[force] (S4P3) → 4^{th} (3A)	9^{th}	9^{th}
3.10: Mixed Triple Product of Three Vectors $\vec{S}\bullet\left(\vec{P}\times\vec{Q}\right)=\begin{vmatrix} S_x & S_y & S_z \\ P_x & P_y & P_z \\ Q_x & Q_y & Q_z \end{vmatrix}$	[four operations] (M1N3) → 1^{st} (1A) + (M2N3) → 2^{nd} (2A) [special math: vector product or cross product] → To be taught as a special math topic	[force] (S4P3) → 4^{th} (3A)	9^{th}	
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)	[four operations] (M1N3) → 1^{st} (1A) + (M2N3) → 2^{nd} (2A) [special math: scalar product] → To be taught as a special math topic	[force] (S4P3) → 4^{th} (3A)	9^{th}	
3.12: Moment of a Couple $\vec{M}=\vec{r}\times\vec{F} \quad M=rF\sin\theta=Fd$	[four operations] (M1N3) → 1^{st} (1A) + (M2N3) → 2^{nd} (2A) [trigonometric functions] (MA2G2) → 10^{th} (2F) → To be taught as a special math topic [special math: vector product or cross product] → To be taught as a special math topic	[force] (S4P3) → 4^{th} (3A) [motion] (SKP2) → K (3A) [lever] (S4P3) → 4^{th} (3A)	9^{th}	
3.13: Equivalent Couples $F_1d_1=F_2d_2$	[four operations] (M1N3) → 1^{st} (1A) + (M2N3) → 2^{nd} (2A) [geometry: point, axis/line, 3D body] (M6G1) (M6G2) (M6M3) → 6^{th} (2B)	[force] (S4P3) → 4^{th} (3A) [motion] (SKP2) → K (3A) [lever] (S4P3) → 4^{th} (3A)	6^{th}	

Table 8 (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) [special math: vector product or cross product] → To be taught as a special math topic	[force] (S4P3) → 4th (3A)	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)	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) [special math: vector product or cross product] → To be taught as a special math topic	[force] (S4P3) → 4th (3A)	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) [special math: vector product or cross product] → To be taught as a special math topic	[force] (S4P3) → 4th (2A) or (S8P3) → 8th (3C)	9th	
3.18: Equivalent Systems of Forces $\sum \vec{F} = \sum \vec{F}' \quad \& \quad \sum \vec{M}_0 = \sum \vec{M}'_0$ $\sum \vec{F} = \sum \vec{F}' \quad and \quad \sum \vec{M}_O = \vec{M}_O'$ $\sum F_x = \sum F'_x \quad \sum F_y = \sum F'_y \quad \sum F_z = \sum F'_z$ $\sum M_x = \sum M'_x \quad \sum M_y = \sum M'_y \quad \sum M_z = \sum M'_z$	[four operations] (M1N3) → 1st (1A) + (M2N3) → 2nd (2A) [coordinate system] (M4G3) → 4th (2B)	[force] (S4P3) → 4th (2A) 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 (2A) or (S8P3) → 8th (3C)	9th	
3.20: Further Reduction of a System of Forces	[coordinate system] (M4G3) → 4th (2B)	[force] (S4P3) → 4th (2A) or (S8P3) → 8th (3C)	8th	

Table 8 (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 $p = \frac{M_1}{R}$ $M_1 = \frac{\vec{R} \bullet \vec{M}_O^R}{R}$ $p = \frac{M_1}{R} = \frac{\vec{R} \bullet \vec{M}_O^R}{R^2}$ $\vec{M}_1 = p\vec{R} \rightarrow \vec{M}_1 + \vec{r} \times \vec{R} = \vec{M}_O^R$; $p\vec{R} + \vec{r} \times \vec{R} = \vec{M}_O^R$	[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 [special math: scalar product] → To be taught as a special math topic [special math: vector product or cross product] → To be taught as a special math topic	[force] (S4P3) → 4th (2A) or (S8P3) → 8th (3C) [motion] (SKP2) → K (2A) [lever] (S4P3) → 4th (2A)	9th	9th
Chapter 4: Equilibrium of Rigid Bodies				
4.1: Introduction $\sum \vec{F} = 0$ $\sum F_x = 0$ $\sum F_y = 0$ $\sum F_z = 0$ $\sum \vec{M}_O = \sum (\vec{r} \times \vec{F}) = 0$ $\sum M_x = 0$ $\sum M_y = 0$ $\sum M_z = 0$	[summation/addition] (M6N1) → 6th (1A) or (MA1A3) → 9th (2E) → To be taught as a special math topic [coordinate system] (M4G3) → 4th (2B)	[force] (S4P3) → 4th (2A) 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				

Table 8 (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)				
<u>Equilibrium in Three Dimensions</u> **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**	[summation/addition] (M6N1) → 6^{th} (1A) or (MA1A3) → 9^{th} (2E) → To be taught as a special math topic [coordinate system] (M4G3) → 4^{th} (2B)	[force] (S4P3) → 4^{th} (2A) or (S8P3) → 8^{th} (3C) [Newton's 3^{rd} Law: Action and Reaction] (SP1) → 9^{th} (3C)	9^{th}	9^{th}
Chapter 5: Distributed Forces: Centroids and Centers of Gravity				
5.1: Introduction **<u>Areas and Lines</u>** **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) → 4^{th} (2B) [summation/addition] (M6N1) → 6^{th} (2A) [integration] → 12^{th} (To be taught)	[force] (S4P3) → 4^{th} (2A) or (S8P3) → 8^{th} (3C) [Newton's Law of Gravitation] (S8P5) → 8^{th} (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) → 6^{th} (2C) [integration] → 12^{th} (To be taught)	[force] (S4P3) → 4^{th} (2A) or (S8P3) → 8^{th} (3C) [Newton's Law of Gravitation] (S8P5) → 8^{th} (3C)	PS	

Table 8 (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] → 12th (To be taught) [coordinate system] (M4G3) → 4th (2B) [two-dimensional figures: circle, arc, triangle, ellipse, parabolic] (M1G1) (M1G2) → 1st (1B) + (MA2G4) → 10th (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) → 4th (2A) or (S8P3) → 8th (3C) [Newton's Law of Gravitation] (S8P5) → 8th (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) → 4th (2B) [summation/addition] (M6N1) → 6th (2A) [measurement: area, weight, thickness] (M6M1) (M6M2) → 6th (2C)	[force] (S4P3) → 4th (2A) or (S8P3) → 8th (3C) [Newton's Law of Gravitation] (S8P5) → 8th (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] → 12th (To be taught) [coordinate system] (M4G3) → 4th (2B) [measurement: area] (M6M1) (M6M2) → 6th (2C)	[force] (S4P3) → 4th (2A) or (S8P3) → 8th (3C) [Newton's Law of Gravitation] (S8P5) → 8th (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] → 12th (To be taught)	[force] (S4P3) → 4th (2A) or (S8P3) → 8th (3C) [Newton's Law of Gravitation] (S8P5) → 8th (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) → 4th (2B) [integration] → 12th (To be taught) [measurement: area] (M6M1) (M6M2) → 6th (2C)	[force] (S4P3) → 4th (2A) or (S8P3) → 8th (3C) [Newton's Law of Gravitation] (S8P5) → 8th (3C)	PS	
5.9: Forces on Submerged Surfaces $w = bp = b\gamma h$	[measurement: area] (M6M1) (M6M2) → 6th (2C)	[force] (S4P3) → 4th (2A) or (S8P3) → 8th (3C)	8th	

Table 8 (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} (2A) 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	[summation/addition] (M6N1) → 6^{th} (2A) [four operations] (M1N3) → 1^{st} (1A) + (M2N3) → 2^{nd} (1A), or (M7N1) → 7^{th} (2A) [coordinate system] (M4G3) → 4^{th} (2B)	[force] (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**	[summation/addition] (M6N1) → 6^{th} (2A) [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] (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				

Table 8 (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	[summation/addition] (M6N1) → 6th (2A) [four operations] (M1N3) → 1st (2A) + (M2N3) → 2nd (1A), or (M7N1) → 7th (2A) [trigonometric functions] (MA2G2) → 10th (2F) → To be taught as a special math topic [coordinate system] (M4G3) → 4th (2B)	[force] (S8P3) → 8th (3C) [Newton's 3rd Law: Action and Reaction] (SP1) → 9th (3C)	9th	9th
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**	[summation/addition] (M6N1) → 6th (2A) [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	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)	[summation/addition] (M6N1) → 6th (2A) [four operations] (M1N3) → 1st (1A) + (M2N3) → 2nd (1A), or (M7N1) → 7th (2A) [integration] → 12th (to be taught) [differentiation] → 12th (to be taught)	[force] (S4P3) → 4th (3A) or (S8P3) → 8th (3C)	PS	

Table 8 (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)				
<u>Cables</u> **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** $y = \frac{wx^2}{2T_O}$	[summation/addition] (M6N1) → 6th (2A) [trigonometric functions] (MA2G2) → 10th (2F) → To be taught as a special math topic [four operations] (M1N3) → 1st (2A) + (M2N3) → 2nd (2A), or (M7N1) → 7th (2A) [square root] (M8N1) → 8th (2A)	[force] (S4P3) → 4th (3A) or (S8P3) → 8th (3C)	8th	PS
7.10: Catenary $T = \sqrt{T_O^2 + w^2 s^2} \quad c = \frac{T_O}{w} \quad T_O = wc \quad W = ws \quad T = w\sqrt{c^2 + s^2}$ $dx = ds\cos\theta = \frac{T_O}{T}ds = \frac{wcds}{w\sqrt{c^2+s^2}}$ $x = \int_O^S \frac{ds}{\sqrt{1+\frac{s^2}{c^2}}} = c\left[\sinh^{-1}\frac{s}{c}\right]_O^S = c\sinh^{-1}\frac{s}{c}$ $s = c\sinh\frac{x}{c} \quad y = c\cosh\frac{x}{c} \quad y^2 - s^2 = c^2 \quad T_O = wc \quad W = ws$ $T = wy \quad h = y_A = c$	[summation/addition] (M6N1) → 6th (2A) [trigonometric functions] (MA2G2) → 9th (2F) [four operations] (M1N3) → 1st (2A) + (M2N3) → 2nd (2A), or (M7N1) → 7th (2A) [square root] (M8N1) → 8th (2A) [integration] → 12th (to be taught) [differentiation] → 12th (to be taught)	[force] (S4P3) → 4th (3A) or (S8P3) → 8th (3C)	PS	

Table 8 (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	[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
8.2: 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 $M = Rr\sin\phi_k \approx Rr\mu_k \quad r_f = r\sin\phi_k \approx r\mu_k$				
8.8: Thrust Bearings. Disk Friction $\Delta M = r\Delta F = \frac{r\mu_k P\Delta A}{\pi(R_2^2 - R_1^2)}$ $M = \frac{\mu_k P}{\pi(R_2^2 - R_1^2)}\int_0^{2\pi}\int_{R_1}^{R_2} r^2 dr d\theta = \frac{\mu_k P}{\pi(R_2^2 - R_1^2)}\int_0^{2\pi}\left[\frac{r^{2+1}}{2+1}\right]_{R_1}^{R_2} d\theta$ $= \frac{\mu_k P}{\pi(R_2^2 - R_1^2)}\int_0^{2\pi}\frac{1}{3}(R_2^3 - R_1^3)d\theta$ $\text{Ring area}: \quad M = \frac{2}{3}\mu_k P\frac{R_2^3 - R_1^3}{R_2^2 - R_1^2} \quad \text{Full circle}: \quad M = \frac{2}{3}\mu_k PR$	[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	

Table 8 (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)	[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

Table 8 (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 **Moments of Inertia of Areas** **9.2: Second Moment, or Moment of Inertia, of an Area** $R=\int kydA=k\int ydA \quad M=\int ky^2dA=k\int y^2dA$ $R=\int \gamma ydA=\gamma\int ydA \quad M_x=\int y^2dA=\gamma\int y^2dA$ **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 [vector product] → To be taught as a special math topic [partial differentiation] → 12th (to be taught) [gradient] → 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

Table 8 (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 (For formulas, refer to p. 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** (For formulas, refer to pp. 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** $I = \int r^2 dm \quad I = k^2 m \quad or \quad k = \sqrt{\frac{I}{m}}$ $I_x = \int (y^2 + z^2)dm \quad I_y = \int (z^2 + x^2)dm$ $I_z = \int (x^2 + y^2)dm$	[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 [vector product] → To be taught as a special math topic [partial differentiation] → 12th (to be taught) [gradient] → 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

Table 8 (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 [vector product] → To be taught as a special math topic [partial differentiation] → 12th (to be taught) [gradient] → 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 $\left.\begin{array}{l} I_{AA',mass} = \int r^2 dm \\ dm = \rho t\,dA \end{array}\right\} I_{AA',mass} = \rho t \int r^2 dA$ $I_{AA',mass} = \rho t I_{AA',area} \quad I_{BB',mass} = \rho t I_{BB',area}$ $I_{CC',mass} = \rho t J_{C,area} \quad I_{CC'} = I_{AA'} + I_{BB'}$ Rectangular Plate $I_{AA',mass} = \rho t I_{AA',area} = \rho t\left(\frac{1}{12}a^3 b\right) \quad I_{BB',mass} = \rho t I_{BB',area} = \rho t\left(\frac{1}{12}ab^3\right)$ $I_{AA'} = \frac{1}{12}ma^2 \quad I_{BB'} = \frac{1}{12}mb^2 \quad I_{CC'} = I_{AA'}+I_{BB'} = \frac{1}{12}m(a^2+b^2)$ Circular Plate $I_{AA',mass} = \rho t I_{AA',area} = \rho t\left(\frac{1}{4}\pi r^4\right) \quad I_{AA'} = I_{BB'} = \frac{1}{4}mr^2$ $I_{CC'} = I_{AA'} + I_{BB'} = \frac{1}{12}mr^2$				

Table 8 (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 {For formulas, refer to p. 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** $I_{OL} = \int p^2 dm = \int \lvert \vec{\lambda} \times \vec{r} \rvert^2 dm$ $= \int \left[(\lambda_x y - \lambda_y x)^2 + (\lambda_y z - \lambda_z y)^2 + (\lambda_z x - \lambda_x z)^2 \right]$ $= \lambda_x^2 \int (y^2 + z^2) dm + \lambda_y^2 \int (z^2 + x^2) dm + \lambda_z^2 \int (x^2 + y^2) dm -$ $2\lambda_x \lambda_y \int xy\ dm - 2\lambda_y \lambda_z \int yz\ dm - 2\lambda_z \lambda_x \int zx\ dm$ $I_{xy} = \int xy\ dm \quad I_{yz} = \int yz\ dm \quad I_{zx} = \int zx\ dm$ $I_{OL} = I_x \lambda_x^2 + I_y \lambda_y^2 + I_z \lambda_z^2 - 2I_{xy} \lambda_x \lambda_y - 2I_{yz} \lambda_y \lambda_{yz} - 2I_{zx} \lambda_z \lambda_x$ $I_{xy} = \bar{I}_{x'y'} + m\overline{xy} \quad I_{yz} = \bar{I}_{y'z'} + m\overline{yz} \quad I_{zx} = \bar{I}_{z'x'} + m\overline{zx}$ **9.17: Ellipsoid of Inertia. Principal Axes of Inertia** $(OQ)\lambda_x = x \quad (OQ)\lambda_y = y \quad (OQ)\lambda_z = z$ $I_x x^2 + I_y y^2 + I_z z^2 - 2I_{xy} xy - 2I_{yz} yz - 2I_{zx} zx = 1$ $I_{x'} x'^2 + I_{y'} y'^2 + I_{z'} z'^2 = 1$ $I_{OL} = I_{x'} \lambda_{x'}^2 + I_{y'} \lambda_{y'}^2 + I_{z'} \lambda_{z'}^2$	[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) → 9th (2F) [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) [vector product] → To be taught as a special math topic [partial differentiation] → 12th (to be taught) [gradient] → 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

Table 8 (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 $\left.\begin{array}{l}\nabla f=(2K)\vec{r}\\K=\text{constant}\\\vec{r}=x\hat{i}+y\hat{j}+z\hat{k}\end{array}\right\}\rightarrow\nabla f=\frac{\partial f}{\partial x}\hat{i}+\frac{\partial f}{\partial y}\hat{j}+\frac{\partial f}{\partial z}\hat{k}$ $f(x,y,z)=I_x x^2+I_y y^2+I_z z^2-2I_{xy}xy-2I_{yz}yz-2I_{zx}zx-1$ ... $\begin{vmatrix}I_x-K & -I_{xy} & -I_{zx}\\-I_{xy} & I_y-K & -I_{yz}\\-I_{zx} & -I_{yz} & I_z-K\end{vmatrix}=0$ (More formulas on p.p. 534-535)	[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) → 9th (2F) [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 [vector product] → To be taught as a special math topic [partial differentiation] → 12th (to be taught) [gradient] → 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

Table 8 (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 [scalar 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 $\delta U = \vec{F}_1 \bullet \delta\vec{r} + \vec{F}_2 \bullet \delta\vec{r} + \ldots + \vec{F}_n \bullet \delta\vec{r}$ $= \left(\vec{F}_1 + \vec{F}_2 + \ldots + \vec{F}_n\right) \bullet \delta\vec{r} \quad \to \quad \delta U = \vec{R} \bullet \delta\vec{r}$				
10.4: Applications of the Principle of Virtual Work $x_B = 2\ell \sin\theta \quad y_C = \ell \cos\theta$ $\delta x_B = 2\ell \cos\theta\delta\theta \quad \delta y_C = -\ell \sin\theta\delta\theta$ $\delta U = \delta U_Q + \delta U_P = -Q\delta x_B - P\delta y_C$ $= -2Q\ell\cos\theta\ \delta\theta + P\ell\sin\theta\ \delta\theta$ $\delta U = 0 \quad \to$ $2Q\ell\cos\theta\ \delta\theta = P\ell\sin\theta\ \delta\theta \quad \to \quad Q = \frac{1}{2} P\tan\theta$ $B_x = -\frac{1}{2} P\tan\theta$				
10.5: Real Machines. Mechanical Efficiency $\delta U = -Q\delta x_B - P\delta y_C - F\delta x_B$ $= -2Q\ell\cos\theta\ \delta\theta + P\ell\sin\theta\ \delta\theta - \mu P\ell\cos\theta\ \delta\theta$ $\delta U = 0 \quad \to \quad 2Q\ell\cos\theta\ \delta\theta = P\ell\sin\theta\ \delta\theta - \mu P\ell\cos\theta\ \delta\theta \quad \to$ $\eta = \frac{\text{output work}}{\text{input work}} = \frac{2Q\ell\cos\theta\ \delta\theta}{P\ell\sin\theta\ \delta\theta}$ $\eta = \frac{2\left(\frac{1}{2}P(\tan\theta - \mu)\right)\ell\cos\theta\ \delta\theta}{P\ell\sin\theta\ \delta\theta} = \frac{P(\tan\theta - \mu)\ell\cos\theta\ \delta\theta}{P\ell\sin\theta\ \delta\theta} = 1 - \mu\cot\theta$				

Table 8 (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 $dU = \vec{F} \bullet d\vec{r} \quad \rightarrow \quad U_{1\rightarrow 2} = \int_{A_1}^{A_2} \vec{F} \bullet d\vec{r}$ $dU = F\, ds \cos\alpha \quad \rightarrow \quad U_{1\rightarrow 2} = \int_{S_1}^{S_2} (F \cos\alpha) ds$ $dU = M d\theta \quad \rightarrow \quad U_{1\rightarrow 2} = \int_{\theta_1}^{\theta_2} M\ d\theta \quad U_{1\rightarrow 2} = M(\theta_2 - \theta_1)$ Work of a weight $dU = -W\, dy \quad \rightarrow \quad U_{1\rightarrow 2} = -\int_{y_1}^{y_2} W\, dy \quad U_{1\rightarrow 2} = -W(y_2 - y_1) = -W$ Work of the force exerted by a spring $F = kx \quad \rightarrow \quad dU = -F\, dx = -kx\, dx$ $U_{1\rightarrow 2} = -\int_{x_1}^{x_2} kx\, dx = \frac{1}{2}kx_1^2 - \frac{1}{2}kx_2^2 \quad U_{1\rightarrow 2} = -\frac{1}{2}(F_1 + F_2)\Delta x$	[integration] → 12th (to be taught) [differentiation] → 12th (to be taught) [trigonometric functions] (MA2G2) → 10th (2F) → To be taught as a special math topic [scalar 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 $U_{1\rightarrow 2} = (V_g)_1 - (V_g)_2 \quad \leftarrow \quad V_g = Wy$ $U_{1\rightarrow 2} = (V_e)_1 - (V_e)_2 \quad \leftarrow \quad V_e = \frac{1}{2}kx^2$ $dU = -dV \quad U_{1\rightarrow 2} = V_1 - V_2$				

Table 8 (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 [scalar 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 $\frac{\partial^2V}{\partial\theta_2^2}>0$				

Table 9
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	○	○	○	○	○	

Table 9 (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 $\vec{F} = F_x\hat{i} + F_y\hat{j} \quad F_x = F\cos\theta \quad F_y = F\sin\theta \quad \tan\theta = \frac{F_y}{F_x} \quad F = \sqrt{F_x^2 + F_y^2}$	○	○	○	○	○	
2.9: Equilibrium of a Particle $R = \sum F = F_1 + F_2 + ... = 0 \quad \Rightarrow \quad R_x = \sum F_x = 0 \quad R_y = \sum F_y = 0 \quad R_z = \sum F_z = 0$	○	○	○	○	○	
2.10: Newton's First Law of Motion	○	○	○	○	○	
2.11: Problems Involving the Equilibrium of a Particle. Free-Body Diagrams	○	○	○	○	○	
<u>Forces in Space</u> **2.12: Rectangular Components of a Force in Space** $F_y = F\cos\theta_y \quad F_h = F\sin\theta_y \quad F_x = F_h\cos\phi = F\sin\theta_y\cos\phi \quad F_z = F_h\sin\phi = F\sin\theta_y\sin\phi$ $F^2 = F_y + F_h = F_y + F_x + F_z \quad \rightarrow \quad F = \sqrt{F_x + F_y + F_z}$ $F_x = F\cos\theta_x \quad F_y = F\cos\theta_y \quad F_z = F\cos\theta_z \quad (0^\circ < \theta_{x,y,z} < 180^\circ)$ $\vec{F} = F_x\hat{i} + F_y\hat{j} + F_z\hat{k} \quad \vec{F} = F\left(\cos\theta_x\hat{i} + \cos\theta_y\hat{j} + \cos\theta_z\hat{k}\right)$ $\cos\theta_x = \frac{F_x}{F} = \frac{d_x}{d} = \frac{R_x}{R} \quad \cos\theta_y = \frac{F_y}{F} = \frac{d_y}{d} = \frac{R_y}{R} \quad \cos\theta_z = \frac{F_z}{F} = \frac{d_z}{d} = \frac{R_z}{R}$ $\theta_{x(y,z)} = \cos^{-1}\frac{F_{x(y,z)}}{F} = \cos^{-1}\frac{d_{x(y,z)}}{d} \quad F = \sqrt{F_x^2 + F_y^2 + F_z^2}$ $\hat{\lambda} = \cos\theta_x\hat{i} + \cos\theta_y\hat{j} + \cos\theta_z\hat{k} \quad \hat{\lambda} = \frac{\vec{F}}{F} \quad \hat{i} = \frac{d_x}{d} \quad \hat{j} = \frac{d_y}{d} \quad \hat{k} = \frac{d_z}{d}$ $\cos^2\theta_x + \cos^2\theta_y + \cos^2\theta_z = 1 \quad \rightarrow \quad \hat{\lambda}_x^2 + \hat{\lambda}_y^2 + \hat{\lambda}_z^2 = 1$	○	○	○	○	○	

Table 9 (Continued).

Engineering Subject: Statics						
<u>Likert Scale (Score of Importance) Note:</u> 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 $\overrightarrow{MN} = d_x\hat{i} + d_y\hat{j} + d_z\hat{k} \quad \hat{\lambda} = \frac{\overrightarrow{MN}}{MN} = \frac{1}{d}\left(d_x\hat{i} + d_y\hat{j} + d_z\hat{k}\right)$ $d_{x(y,z)} = x(y,z)_2 - x(y,z)_1 \quad d = \sqrt{d_x^2 + d_y^2 + d_z^2}$ $\vec{F} = F\hat{\lambda} = \frac{F}{d}\left(d_x^2\hat{i} + d_y^2\hat{j} + d_z^2\hat{k}\right) \quad F_x = \frac{Fd_x}{d} \quad F_y = \frac{Fd_y}{d} \quad F_z = \frac{Fd_z}{d}$	○	○	○	○	○	
2.14: Addition of Concurrent Forces in Space $\vec{R} = \sum \vec{F} \quad R = \sqrt{R_x^2 + R_y^2 + R_z^2} \quad R_x\hat{i} + R_y\hat{j} + R_z\hat{k} = \left(\sum F_x\right)\hat{i} + \left(\sum F_y\right)\hat{j} + \left(\sum F_z\right)\hat{k}$	○	○	○	○	○	
2.15: Equilibrium of a Particle in Space $R = \sum F = F_1 + F_2 + \ldots = 0 \quad \rightarrow \quad R_x = \sum F_x = 0 \quad R_y = \sum F_y = 0 \quad R_z = \sum F_z = 0$ $\begin{bmatrix} a & b & c \\ d & e & f \\ g & h & i \end{bmatrix} \times \begin{bmatrix} x \\ y \\ z \end{bmatrix} = \begin{bmatrix} ax + by + cz \\ dx + ey + fz \\ gx + hy + iz \end{bmatrix} \quad \begin{bmatrix} a & b & c \\ d & e & f \\ g & h & i \end{bmatrix} \times \begin{bmatrix} F_1 \\ F_2 \\ F_3 \end{bmatrix} = \begin{bmatrix} 0 \\ 0 \\ 0 \end{bmatrix}$ $\begin{matrix} R_x = \sum F_x = 0 \\ R_y = \sum F_y = 0 \\ R_z = \sum F_z = 0 \end{matrix} \quad \begin{matrix} aF_1 + bF_2 + cF_3 = 0 \\ dF_1 + eF_2 + fF_3 = 0 \\ gF_1 + hF_2 + iF_3 = 0 \end{matrix} \quad \begin{bmatrix} a & b & c \\ d & e & f \\ g & h & i \end{bmatrix} \times \begin{bmatrix} F_1 \\ F_2 \\ F_3 \end{bmatrix} = \begin{bmatrix} aF_1 + bF_2 + cF_3 \\ dF_1 + eF_2 + fF_3 \\ gF_1 + hF_2 + iF_3 \end{bmatrix}$	○	○	○	○	○	

Table 9 (Continued).

Engineering Subject: Statics						
<u>Likert Scale (Score of Importance) Note:</u> 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 $\vec{M}_0=\vec{r}\times\vec{F}$ $M_0=rF\sin\theta=Fd$ $\vec{r}=\vec{v}^{O\to A}_{position}$ $\theta=\angle_{\vec{r}\to\vec{F}}$ $d\perp\vec{F}$ $\vec{M}_0=\vec{r}\times\vec{F}=\begin{vmatrix}\hat{i} & \hat{j} & \hat{k}\\ x & y & z\\ F_x & F_y & F_z\end{vmatrix}=M_x\hat{i}+M_y\hat{j}+M_z\hat{k}$ $M_x=yF_z-zF_y$ $M_y=-(xF_z-zF_x)=zF_x-xF_z$ $M_z=xF_y-yF_x$	○	○	○	○	○	

Table 9 (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 $\vec{r} \times \left(\vec{F}_1 + \vec{F}_2 + ...\right) = \vec{r} \times \vec{F}_1 + \vec{r} \times \vec{F}_2 + ...$	○	○	○	○	○	
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 $\vec{S} \bullet \left(\vec{P} \times \vec{Q}\right) = \begin{vmatrix} S_x & S_y & S_z \\ P_x & P_y & P_z \\ Q_x & Q_y & Q_z \end{vmatrix}$	○	○	○	○	○	

Table 9 (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 $M_{OL} = \hat{\lambda} \bullet \vec{M}_O = \hat{\lambda} \bullet (\vec{r} \times \vec{F}) = \begin{vmatrix} \lambda_x & \lambda_y & \lambda_z \\ x & y & z \\ F_x & F_y & F_z \end{vmatrix}$ (More formulas on p. pp. 98)	○	○	○	○	○	
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 $\vec{M} = \vec{r} \times \vec{R} = \vec{r} \times (\vec{F}_1 + \vec{F}_2) = \vec{r} \times \vec{F}_1 + \vec{r} \times \vec{F}_2 \quad \vec{M} = \vec{M}_1 + \vec{M}_2$	○	○	○	○	○	
3.15: Couples Can Be Represented by Vectors	○	○	○	○	○	
3.16: Resolution of a Given Force Into a Force at *O* and a Couple $\vec{M}_{O'} = \vec{r}' \times \vec{F} = (\vec{r} + \vec{s}) \times \vec{F} = \vec{r} \times \vec{F} + \vec{s} \times \vec{F} \quad \vec{M}_{O'} = \vec{M}_O + \vec{s} \times \vec{F}$	○	○	○	○	○	
3.17: Reduction of a System of Forces to One Force and One Couple $\vec{R} = \sum \vec{F} \quad \vec{M}_O^R = \sum \vec{M}_O = \sum (\vec{r} \times \vec{F}) \quad \vec{M}_{O'}^R = \vec{M}_O + \vec{s} \times \vec{R} \quad \vec{r} = x\hat{i} + y\hat{j} + z\hat{k}$ $\vec{F} = F_x\hat{i} + F_y\hat{j} + F_z\hat{k} \quad \vec{R} = R_x\hat{i} + R_y\hat{j} + R_z\hat{k} \quad \vec{M}_O^R = M_x^R\hat{i} + M_y^R\hat{j} + M_z^R\hat{k}$	○	○	○	○	○	

Table 9 (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* $\sum \vec{M}_O = \vec{M}_O'$ $\sum F_x = \sum F'_x$ $\sum F_y = \sum F'_y$ $\sum F_z = \sum F'_z$ $\sum M_x = \sum M'_x$ $\sum M_y = \sum M'_y$ $\sum M_z = \sum M'_z$	O	O	O	O	O	
3.19: Equipollent Systems of Vectors	O	O	O	O	O	
3.20: Further Reduction of a System of Forces	O	O	O	O	O	
3.21: Reduction of a System of Forces to a Wrench $p = \frac{M_1}{R}$ $M_1 = \frac{\vec{R} \bullet \vec{M}_O^R}{R}$ $p = \frac{M_1}{R} = \frac{\vec{R} \bullet \vec{M}_O^R}{R^2}$ $\vec{M}_1 = p\vec{R}$ $\rightarrow$ $\vec{M}_1 + \vec{r} \times \vec{R} = \vec{M}_O^R$ $p\vec{R} + \vec{r} \times \vec{R} = \vec{M}_O^R$	O	O	O	O	O	
Chapter 4: Equilibrium of Rigid Bodies						
4.1: Introduction $\sum \vec{F} = 0$ $\sum F_x = 0$ $\sum F_y = 0$ $\sum F_z = 0$ $\sum \vec{M}_O = \sum (\vec{r} \times \vec{F}) = 0$ $\sum M_x = 0$ $\sum M_y = 0$ $\sum M_z = 0$	O	O	O	O	O	
4.2: Free-Body Diagram	O	O	O	O	O	
<u>Equilibrium in Two Dimensions</u> **4.3: Reactions at Supports and Connections for a Two-Dimensional Structure**	O	O	O	O	O	
4.4: Equilibrium of a Rigid Body in Two Dimensions $F_z = 0$ $M_x = M_y = 0$ $M_z = M_O$ $\sum F_x = 0$ $\sum F_y = 0$ $\sum M_O = 0$ $\sum M_A = 0$ $\sum M_B = 0$ $\sum M_C = 0$	O	O	O	O	O	

Table 9 (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** $\sum \vec{F} = 0 \quad \sum \vec{M}_O = \sum \left(\vec{r} \times \vec{F}\right) = 0 \quad \sum F_x = 0 \quad \sum F_y = 0 \quad \sum F_z = 0 \quad \sum M_x = 0 \quad \sum M_y = 0 \quad \sum M_z = 0$	○	○	○	○	○	
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	○	○	○	○	○	

Table 9 (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	○	○	○	○	○	

Table 10
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** $Plate: \sum F_z: \; W = \Delta W_1 + \Delta W_2 + ... + \Delta W_n \quad \sum M_y: \; \bar{x}W = x_1 \Delta W + x_2 \Delta W + ... + x_n \Delta W \quad \sum M_x: \; \bar{y}W = y_1 \Delta W + y_2 \Delta W + ... + y_n \Delta W$ $W = \int dW \quad \bar{x}W = \int x dW \quad \bar{y}W = \int y dW$ $Wire: \sum M_y: \; \bar{x}W = \sum x\Delta W \quad \sum M_x: \; \bar{y}W = \sum y\Delta W$	○	○	○	○	○	
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 $Q_y = \bar{x}A = \int \bar{x}_{el} dA \quad Q_x = \bar{y}A = \int \bar{y}_{el} dA$	○	○	○	○	○	

Table 10 (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 $\bar{x}V = \int \bar{x}_{el} dV \quad \bar{y}V = \int \bar{y}_{el} dV \quad \bar{z}V = \int \bar{z}_{el} dV \quad \bar{x}V = \int \bar{x}_{el} dV$	○	○	○	○	○	

Table 10 (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 $\frac{dV}{dx} = -w \quad V_D - V_C = -\int_{x_C}^{x_D} w dx = -wx = = \text{-(Area under load curve between C an D)}$ $\frac{dM}{dx} = V \quad M_D - M_C = \int_{x_C}^{x_D} V dx = -\text{(Area under shear curve between C an D)}$	○	○	○	○	○	
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 $y = \frac{wx^2}{2T_O}$	○	○	○	○	○	

Table 10 (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 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						
8.1: Introduction	○	○	○	○	○	
8.2: The Laws of Dry Friction. Coefficients of Friction $F_m=\mu_s N$ $F_k=\mu_k N$	○	○	○	○	○	
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 $Q=P\frac{a}{r}$ $L=nP$	○	○	○	○	○	
8.7: Journal Bearings. Axle Friction $M=Rr\sin\phi_k\approx Rr\mu_k$ $r_f=r\sin\phi_k\approx r\mu_k$	○	○	○	○	○	

Table 10 (Continued).

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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 8: Friction (Continued)						
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 : $M = \frac{2}{3}\mu_k PR$	O	O	O	O	O	
8.9: Wheel Friction. Rolling Resistance $\Pr = Wb$	O	O	O	O	O	
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)	O	O	O	O	O	
Chapter 9: Distributed Forces: Moments of Inertia						
9.1: Introduction	O	O	O	O	O	
Moments of Inertia of Areas **9.2: Second Moment, or Moment of Inertia, of an Area** $R = \int kydA = k\int ydA$ $M = \int ky^2 dA = k\int y^2 dA$ $R = \int \gamma ydA = \gamma\int ydA$ $M_x = \int y^2 dA = \gamma\int y^2 dA$	O	O	O	O	O	

Table 10 (Continued).

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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 9: Distributed Forces: Moments of Inertia (Continued)						
9.3: Determination of the Moment of Inertia of an Area by Integration $I_x = \int y^2 dA \quad I_y = \int x^2 dA \quad dA = b\, dy \quad dI_x = y^2 b\, dy$ $I_x = \int_O^h by^2 dy = \frac{1}{3}BH^3 \quad dI_x = \frac{1}{3}y^3 dx \quad dI_y = x^2 dA = x^2 y dx$	○	○	○	○	○	
9.4: Polar Moment of Inertia $J_O = \int r^2\ dA = \int (x^2 + y^2) dA = \int y^2 dA + \int x^2 dA \quad J_O == I_x + I_y$	○	○	○	○	○	
9.5: Radius of Gyration of an Area $I_x = k_x^2 A \ \rightarrow\ k_x = \sqrt{\frac{I_x}{A}} \quad I_y = k_y^2 A \ \rightarrow\ k_y = \sqrt{\frac{I_y}{A}} \quad J_O = k_O^2 A \ \rightarrow\ k_O = \sqrt{\frac{J_O}{A}}$	○	○	○	○	○	
9.6: Parallel-Axis Theorem $I = \int y^2 dA$ $I = \int y^2 dA = \int (y' + d)^2 dA = \int y'^2\ dA + 2d \int y' dA + d^2 \int dA$ $I = \bar{I} + Ad^2 \quad k^2 = \bar{k}^2 + d^2 \quad J_O = \bar{J}_O + Ad^2 \quad or \quad k_O^2 = \bar{k}_O^2 + d^2$	○	○	○	○	○	
9.7: Moments of Inertia of Composite Areas (For formulas, refer to p. 485)	○	○	○	○	○	
9.8: Product of Inertia $I_{xy} = \int xy\ dA = \int (x' + \bar{x})(y' + \bar{y}) dA = \int x' y' dA + \bar{y} \int x' dA + \bar{x} \int y' dA + \overline{xy} \int dA \quad I_{xy} == \bar{I}_{x'y'} + \overline{xy} A$	○	○	○	○	○	
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	○	○	○	○	○	

Table 10 (Continued).

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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 9: Distributed Forces: Moments of Inertia (Continued)						
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 $x = x' + \bar{x} \quad y = y' + \bar{y} \quad z = z' + \bar{z} \quad I_x = \int (y^2 + z^2) dm$ $I_x = \bar{I}_{x'} + m(\bar{y}^2 + \bar{z}^2) = \int [(y' + \bar{y})^2 + (z' + \bar{z})^2] dm$ $= \int (y'^2 + z'^2) dm + 2\bar{y} \int y' dm + 2\bar{z} \int z' dm + (\bar{y}^2 + \bar{z}^2) \int dm$ $I_y = \bar{I}_{y'} + m(\bar{z}^2 + \bar{x}^2) \quad I_z = \bar{I}_{z'} + m(\bar{x}^2 + \bar{y}^2) \quad I = \bar{I} + md^2 \quad k^2 = \bar{k}^2 + d^2$	○	○	○	○	○	

Table 10 (Continued).

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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 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	○	○	○	○	○	

Table 10 (Continued).

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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 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 $I_{OL} = \int p^2 dm = \int \lvert \vec{\lambda} \times \vec{r} \rvert^2 dm = \int \left[(\lambda_x y - \lambda_y x)^2 + (\lambda_y z - \lambda_z y)^2 + (\lambda_z x - \lambda_x z)^2 \right]$ $= \lambda_x^2 \int (y^2 + z^2) dm + \lambda_y^2 \int (z^2 + x^2) dm + \lambda_z^2 \int (x^2 + y^2) dm -$ $2\lambda_x \lambda_y \int xy\ dm - 2\lambda_y \lambda_z \int yz\ dm - 2\lambda_z \lambda_x \int zx\ dm$ $I_{xy} = \int xy\ dm \quad I_{yz} = \int yz\ dm \quad I_{zx} = \int zx\ dm$ $I_{OL} = I_x \lambda_x^2 + I_y \lambda_y^2 + I_z \lambda_z^2 - 2I_{xy} \lambda_x \lambda_y - 2I_{yz} \lambda_y \lambda_{yz} - 2I_{zx} \lambda_z \lambda_x$ $I_{xy} = \bar{I}_{x'y'} + m\overline{xy} \quad I_{yz} = \bar{I}_{y'z'} + m\overline{yz} \quad I_{zx} = \bar{I}_{z'x'} + m\overline{zx}$	○	○	○	○	○	
9.17: Ellipsoid of Inertia. Principal Axes of Inertia $(OQ)\lambda_x = x \quad (OQ)\lambda_y = y \quad (OQ)\lambda_z = z \quad I_x x^2 + I_y y^2 + I_z z^2 - 2I_{xy} xy - 2I_{yz} yz - 2I_{zx} zx = 1$ $I_{x'} x'^2 + I_{y'} y'^2 + I_{z'} z'^2 = 1 \quad I_{OL} = I_{x'} \lambda_{x'}^2 + I_{y'} \lambda_{y'}^2 + I_{z'} \lambda_{z'}^2$	○	○	○	○	○	

Table 10 (Continued).

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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 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)	○	○	○	○	○	

Table 10 (Continued).

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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						
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 $\delta U = -Q\delta x_B - P\delta y_C - F\delta x_B = -2Q\ell\cos\theta\ \delta\theta + P\ell\sin\theta\ \delta\theta - \mu P\ell\cos\theta\ \delta\theta$ $\delta U = 0 \quad \rightarrow \quad 2Q\ell\cos\theta\ \delta\theta = P\ell\sin\theta\ \delta\theta - \mu P\ell\cos\theta\ \delta\theta \quad \rightarrow$ $\eta = \frac{\text{output work}}{\text{input work}} = \frac{2Q\ell\cos\theta\ \delta\theta}{P\ell\sin\theta\ \delta\theta}$ $\eta = \frac{2\left(\frac{1}{2}P(\tan\theta - \mu)\right)\ell\cos\theta\ \delta\theta}{P\ell\sin\theta\ \delta\theta} = \frac{P(\tan\theta-\mu)\ell\cos\theta\ \delta\theta}{P\ell\sin\theta\ \delta\theta} = 1 - \mu\cot\theta$	○	○	○	○	○	

Table 10 (Continued).

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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)						
10.6: Work of a Force during a Finite Displacement $dU = \vec{F} \bullet d\vec{r} \rightarrow U_{1\to 2} = \int_{A_1}^{A_2} \vec{F} \bullet d\vec{r}$ $\quad dU = F\ ds \cos\alpha \rightarrow U_{1\to 2} = \int_{S_1}^{S_2} (F\cos\alpha) ds$ $dU = Md\theta \rightarrow U_{1\to 2} = \int_{\theta_1}^{\theta_2} M\ d\theta \quad U_{1\to 2} = M(\theta_2 - \theta_1)$ 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 $U_{1\to 2} = (V_g)_1 - (V_g)_2 \leftarrow V_g = Wy \quad U_{1\to 2} = (V_e)_1 - (V_e)_2 \leftarrow V_e = \frac{1}{2}kx^2$ $dU = -dV \quad U_{1\to 2} = V_1 - V_2$	○	○	○	○	○	

Table 10 (Continued).

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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 $\frac{dV}{d\theta}=0 \quad \frac{d^2V}{d\theta^2}>0:\text{stable equilibrium} \quad \frac{dV}{d\theta}=0 \quad \frac{d^2V}{d\theta^2}<0:\text{unstable equilibrium}$ $\frac{\partial V}{\partial\theta_1}=\frac{\partial V}{\partial\theta_2}=0 \quad \left(\frac{\partial^2V}{\partial\theta_1\partial\theta_2}\right)^2-\frac{\partial^2V}{\partial\theta_1^2}\frac{\partial^2V}{\partial\theta_2^2}<0 \quad \frac{\partial^2V}{\partial\theta_1^2}>0 \text{ or } \frac{\partial^2V}{\partial\theta_2^2}>0$	○	○	○	○	○	