Statics3() Statics (3 dimensional) 4-24-08

By Don Benson dnbnsn@cox.net

This program solves three dimensional statics (equilibrium) problems. This update allows the solution of more complex structures, such as trusses, by enabling its application to components of a structure as well as to the structure as a whole. Most commonly, the program would be used for the whole structure first to determine any external forces or couples, then to find forces in members or forces acting at a joint. For a structure as a whole or for a component of a structure by itself, a maximum of 6 unknowns can be found if forces are applied at more than one point, or 3 if all forces are applied at one point. If there more unknowns than equations, you will be prompted to choose a component, which could be a single member, a section, or a joint, involving some of the same unknowns so more equations are generated, perhaps allowing solution.

After an origin is chosen, each force and the position vector of its point of application (relative to the origin), as well as any couples, are entered. Vectors can be entered in rectangular coordinates, or as a given magnitude along a line between two specified points. The previous version of Statics3() allowed the use of spherical coordinates, but I've found very little use for them. The program requires that for each force, either the force or its position vector or both, be known. This requirement, and the elimination of angular unknowns, yields linear force and torque equations. Each unknown must be represented by a two letter variable in alphabetical order, for example, ax, ay, az, bt, ce, but not ba, dc, gd.

Solutions are found by means of the TI Simultaneous Equation Solver. Vector magnitudes or vector components can be solved for, but not angles. Angular unknowns can usually be avoided by using components or by specifying direction along the line between two given points. Then angles can be found, if necessary, by rectangular to spherical conversion. Solutions are saved and copied to the home screen for use in further calculations.

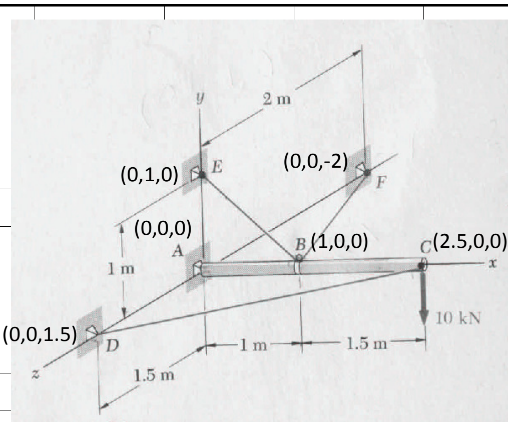
Statics3() can be used for two dimensional cases by setting *z* components of forces and *x* and *y* components of couples to 0, but it's easier to use Statics2().

Copyto_h(), by Samuel Stearley, is used in Statics3() to copy results to the home screen. Place Statics3() and Copyto_h() in the same folder, then run Statics3(). The TI Simultaneous Equation Solver must also be installed on your calculator.

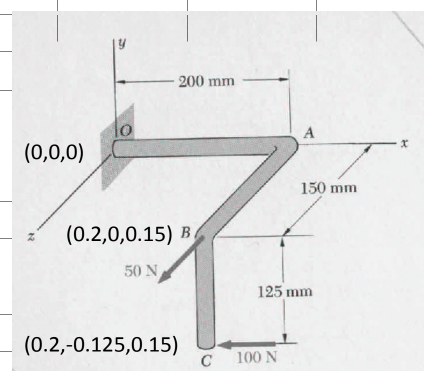
For 2 dimensional cases, see Statics2().

The following examples are from Vector Mechanics for Engineers, Statics, 3rd ed., Beer and Johnston, McGraw-Hill.

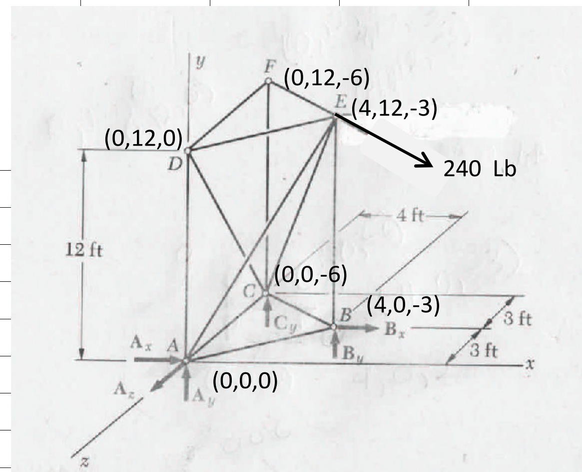
Ex. 1:	A 2.5 m boom is held by a ball and socket at A and by two cables EBF and DC; the cable EBF passes around a frictionless pulley at B. Determine the reaction at A and the tension in each cable.							
	Run Statics3().							
	Choose YES to delete 2 letter variables when starting a new problem. Choose NO if continuing to another component of the same structure.							
	5 Forces							
	0 Couples							
	Position Vector		Force Comp.	or	Force Magn.	From P1	To P2	
#1:	0,0,0		ax,ay,az					
#2:	2.5,0,0		0,-10,0					
#3:	2.5,0,0				cd	2.5,0,0	0,0,1.5	
#4:	1,0,0				bt	1,0,0	0,1,0	
#5:	1,0,0				bt	1,0,0	0,0,-2	
	Calculate							
	ax =	61.8932		Results are saved under the variable name				
	ay =	-15		and are copied to the home screen.				
	az =	18.9737						
	bt =	35.3553						
	cd =	24.5855						



Ex. 2:	The bent member at right has a fixed end at O and is subjected to the two forces shown. Determine the reaction at O.							
	Run Statics3().							
	Choose YES to delete 2 letter variables when starting a new problem.							
	3 Forces							
	1 Couple							
	Position Vector		Force Comp.	or	Force Magn.	From P1	To P2	
#1:	0,0,0		ox,oy,oz					
#2:	0.2,0,0.15		0,0,50					
#3:	0.2,-0.125,0.15		-100,0,0					
	Couple Comp.	or	Magn.	From P1	To P2			
#1:	mx,my,mz							
	Calculate							
	mx =	0						
	my =	25						
	mz =	12.5						
	ox =	100						
	oy =	0						
	oz =	-50						



Ex. 3: The three dimensional truss is supported by the six reactions shown. If a 240 lb load is applied at E parallel to member EF and is directed away from the truss, determine the reactions and the force in each member.



Run Statics3().

Choose YES to delete 2 letter variables when starting a new problem.

Consider structure as a whole.

4 Forces

0 Couples

	Position Vector	Force Comp.	or	Force Magn.	From P1	To P2
#1:	0,0,0	ax,ay,az				
#2:	4,0,-3	bx,by,0				
#3:	0,0,-6	0,cy,0				
#4:	4,12,-3			240	0,12,-6	4,12,-3

Copying and pasting the position vector saves time in entering P1 and P2.

Calculate

ax =	192	
ay =	1.00E-11	≈0
az =	-144	
bx =	-384	
by =	576	
cy =	-576	

To find forces in members, apply Statics3() to individual joints. Only 3 equations are generated at each joint, so if possible, start with a joint with 3 unknowns. If you have more than 3 unknowns at a joint, you will be instructed to choose additional components until sufficient equations are formed.

B (4,0,-3)

Run Statics3().

Choose NO , do not delete 2 letter variables. The values already found can be used in calculations.

4 Forces

0 Couples

	Position Vector	Force Comp.	or	Force Magn.	From P1	To P2
#1:	4,0,-3	bx,by,0				
#2:	4,0,-3			be	4,0,-3	4,12,-3
#3:	4,0,-3			ab	4,0,-3	0,0,0
#4:	4,0,-3			bc	4,0,-3	0,0,-6

Calculate

ab =	-240
bc =	-240
be =	-576

Since the directions used for forces were away from the joint, a positive value means the member is in tension: a negative value means compression.

	A (0,0,0)								
	Choose NO , do not delete 2 letter variables. The values already found can be used in calculations.								
	5 Forces								
	0 Couples								
	Position Vector		Force Comp.	or	Force Magn.	From P1	To P2		
#1:	0,0,0		ax,ay,az						
#2:	0,0,0				ac	0,0,0	0,0,-6		
#3:	0,0,0				ad	0,0,0	0,12,0		
#4:	0,0,0				ab	0,0,0	4,0,-3		
#5:	0,0,0				ae	0,0,0	4,12,-3		
	Calculate								
	ac =	0							
	ad =	-1.00E-11	≈0						
	ae =	0							
	D (0,12,0)								
	Choose NO , do not delete 2 letter variables. The values already found can be used in calculations.								
	4 Forces								
	0 Couples								
	Position Vector		Force Comp.	or	Force Magn.	From P1	To P2		
#1:	0,12,0				ad	0,12,0	0,0,0		
#2:	0,12,0				df	0,12,0	0,12,-6		
#3:	0,12,0				cd	0,12,0	0,0,-6		
#4:	0,12,0				de	0,12,0	4,12,-3		
	Calculate								
	cd =	1.12E-11	≈0						
	de =	0							
	df =	-5.00E-12	≈0						
	E (4,12,-3)								
	Choose NO , do not delete 2 letter variables. The values already found can be used in calculations.								
	6 Forces								
	0 Couples								
	Position Vector		Force Comp.	or	Force Magn.	From P1	To P2		
#1:	4,12,-3				240	0,12,-6	4,12,-3		
#2:	4,12,-3				be	4,12,-3	4,0,-3		
#3:	4,12,-3				de	4,12,-3	0,12,0		
#4:	4,12,-3				ef	4,12,-3	0,12,-6		
#5:	4,12,-3				ce	4,12,-3	0,0,-6		
#6:	4,12,-3				ae	4,12,-3	0,0,0		
	Calculate								
	ce =	624							
	ef =	2.75E-10	≈0						

	F (0,12,-6)								
	Choose NO , do not delete 2 letter variables. The values already found can be used in calculations.								
	3 Forces								
	0 Couples								
	Position Vector		Force Comp.	or	Force Magn.	From P1	To P2		
#1:	0,12,-6				df	0,12,-6	0,12,0		
#2:	0,12,-6				ef	0,12,-6	4,12,-3		
#3:	0,12,-6				cf	0,12,-6	0,0,-6		
	Calculate								
	cf =	0							
	ax =	192							
	ay =	1.00E-11	≈0						
	az =	-144							
	bx =	-384							
	by =	576							
	cy =	-576							
	ab =	-240							
	bc =	-240							
	be =	-576							
	ac =	0							
	ad =	-1.00E-11	≈0						
	ae =	0							
	cd =	1.12E-11	≈0						
	de =	-1.01E-12	≈0						
	df =	-4.35E-12	≈0						
	ce =	624							
	ef =	2.75E-10	≈0						
	cf =	0							