

The background features the official seal of the Georgia Institute of Technology. It is a circular emblem with a blue outer ring containing the text "GEORGIA INSTITUTE OF TECHNOLOGY" at the top and "1885" at the bottom. Inside the ring is a yellow gear-like border. The center of the seal depicts a stylized figure holding a torch and a scroll, with a gear and a compass visible in the background.

Function, Structure and Morph Charts

ME – 2110

Creative Decisions and Design

Thomas R. Kurfess, Ph.D., P.E.

HUSCO/Ramirez Distinguished Chair in Fluid Power and Motion Control

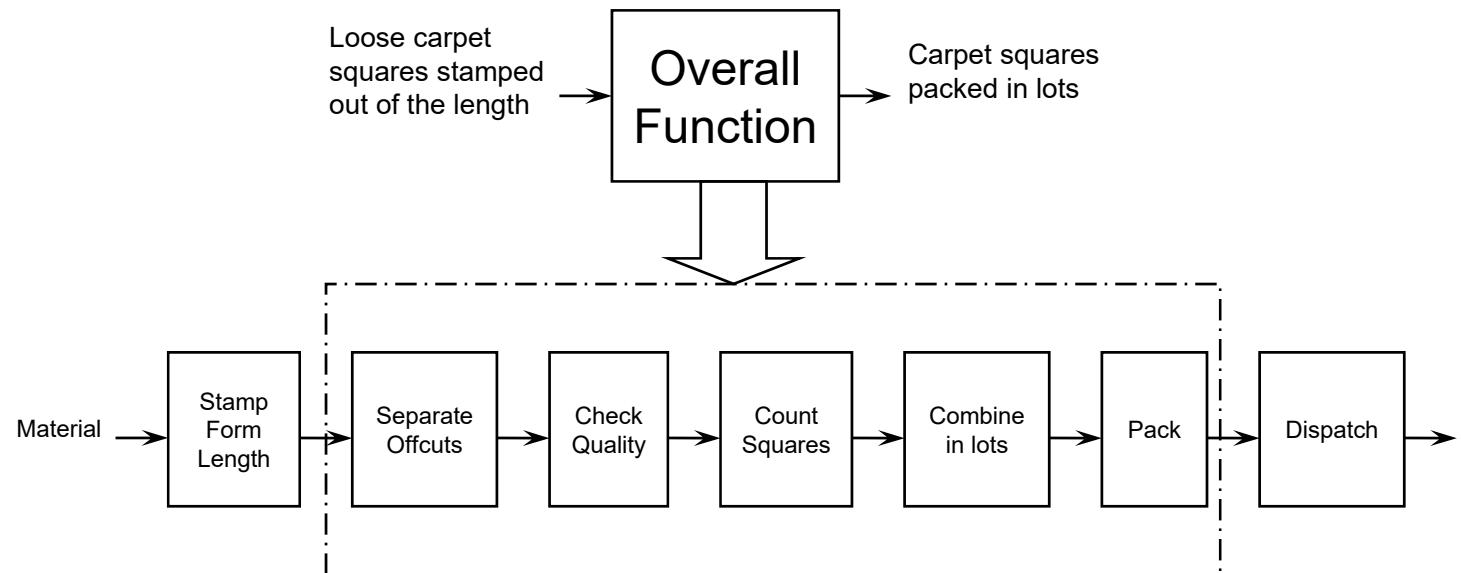
Woodruff School of Mechanical Engineering

Georgia Institute of Technology

Atlanta, Georgia USA

Packing of Carpet Squares

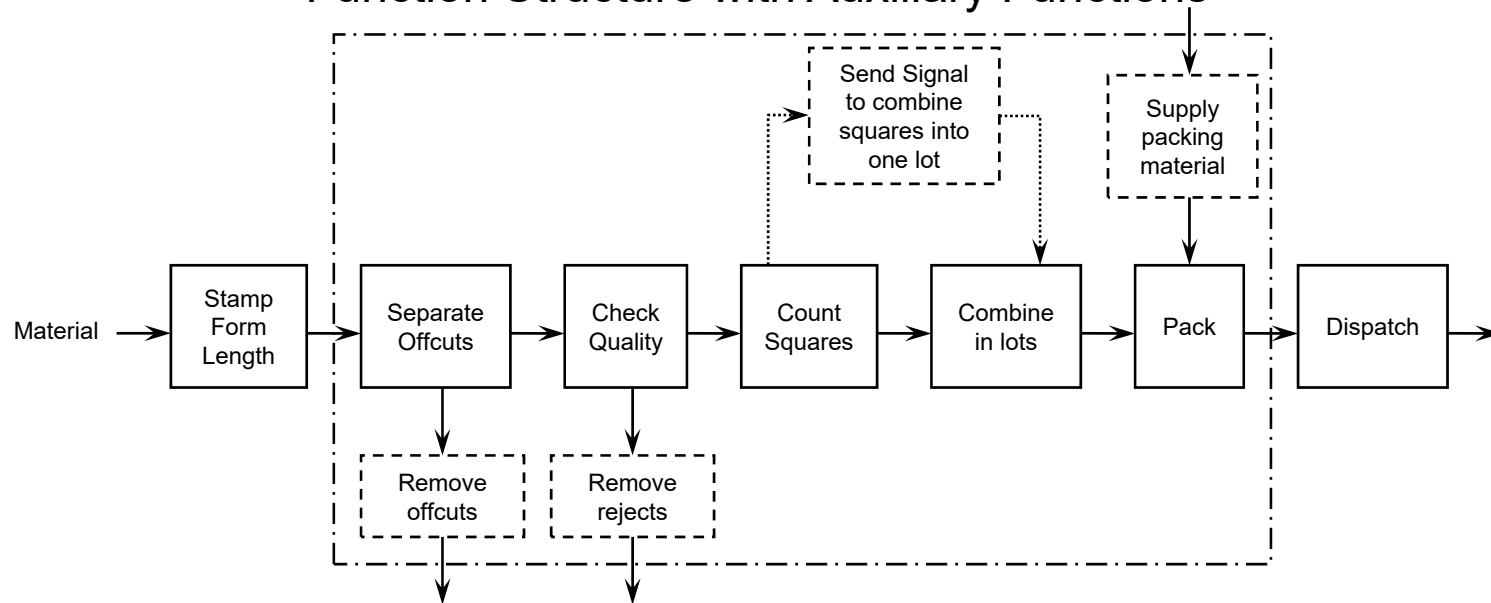
Function Structure



→ Material Flow Main Function System Boundary

Packing of Carpet Squares

Function Structure with Auxiliary Functions

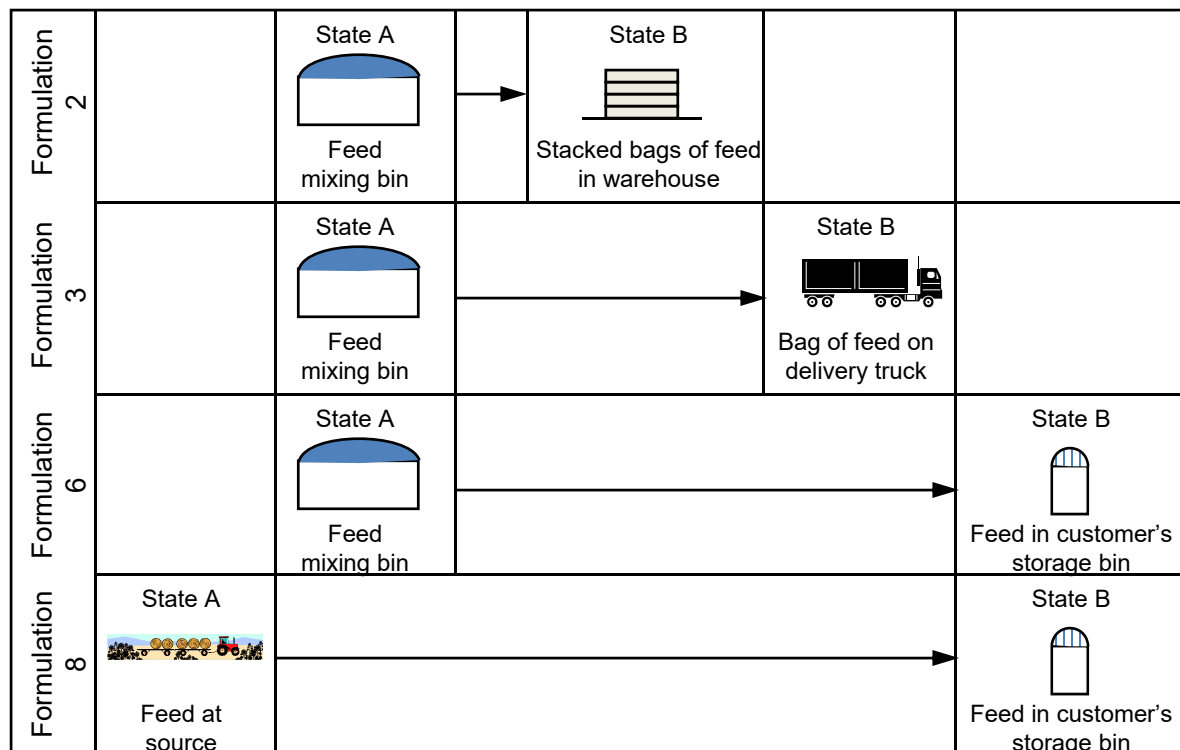


- Material Flow
- Signal Flow
- Main Function
- System Boundary
- Auxiliary Function

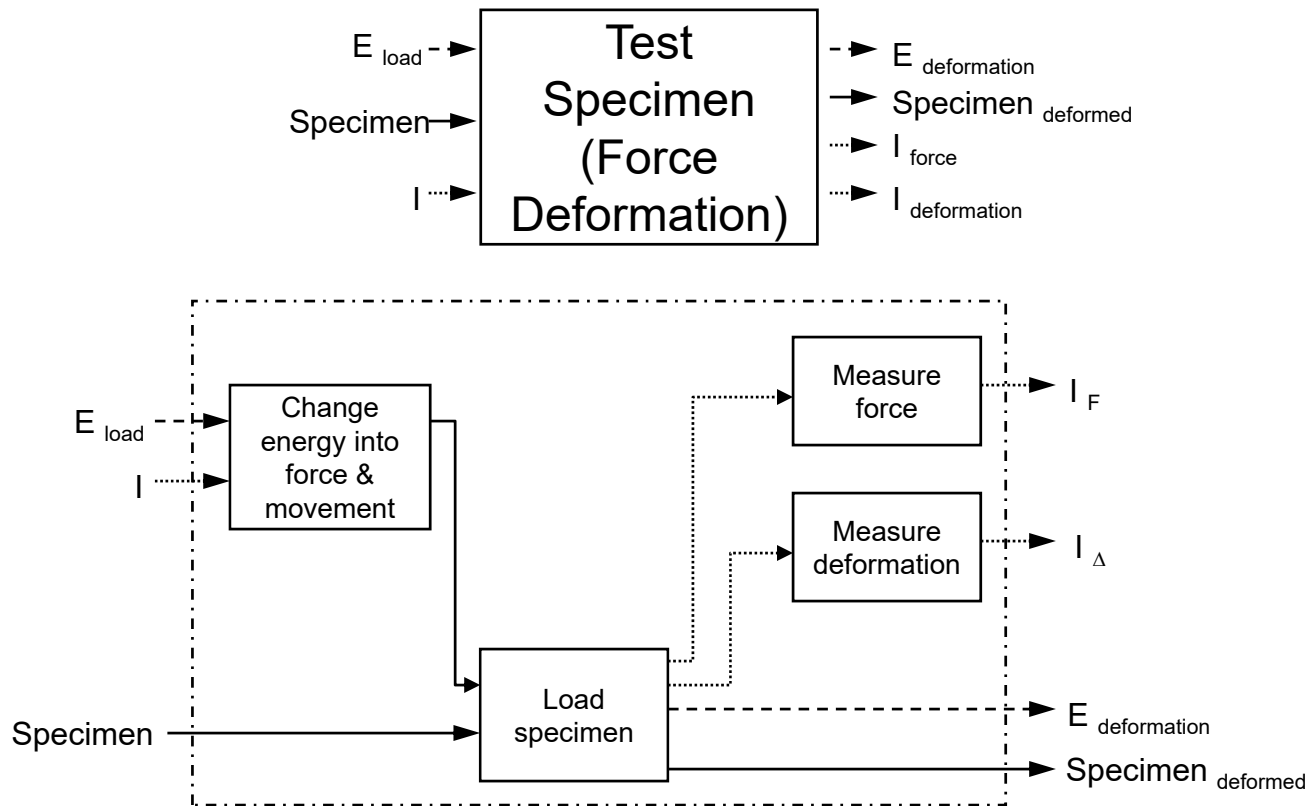
Formulations for Feed Distribution

A = Initial State

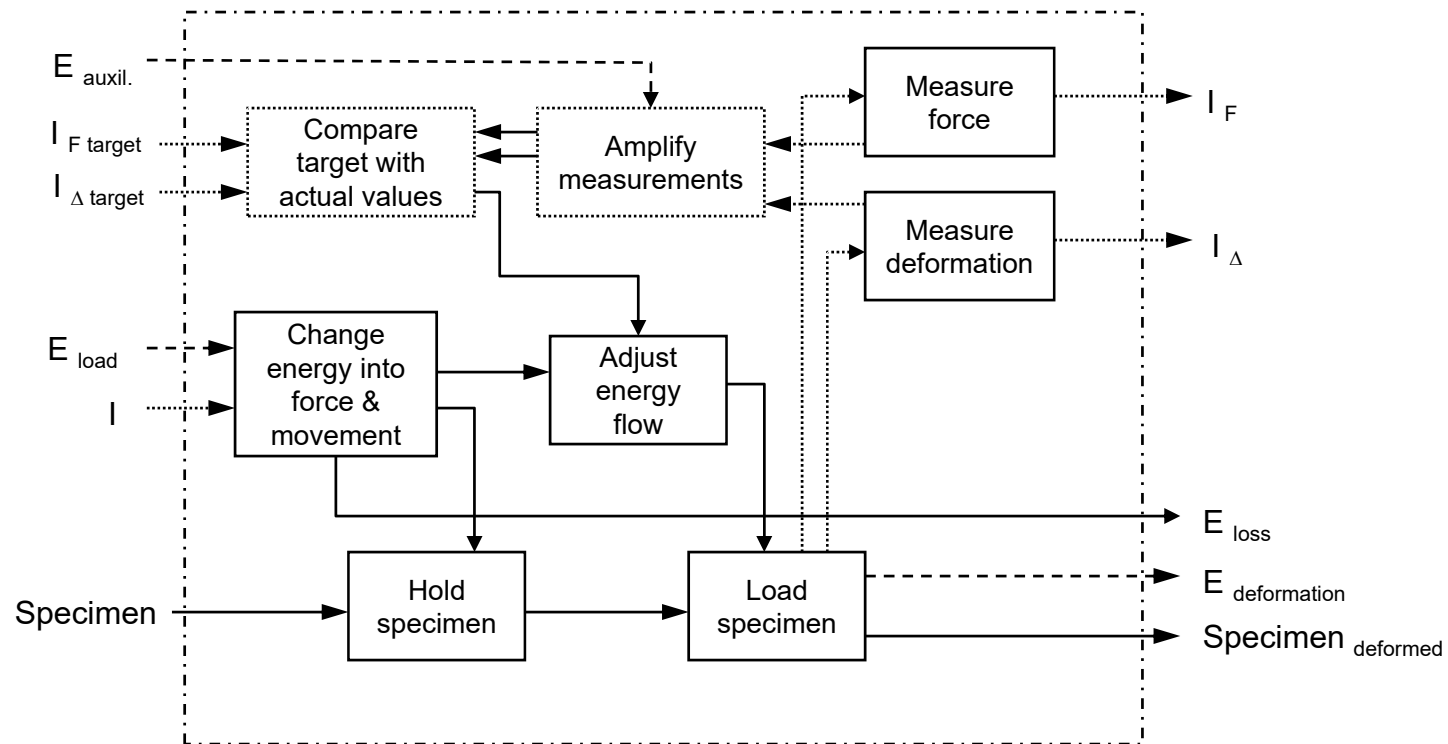
B = Final State



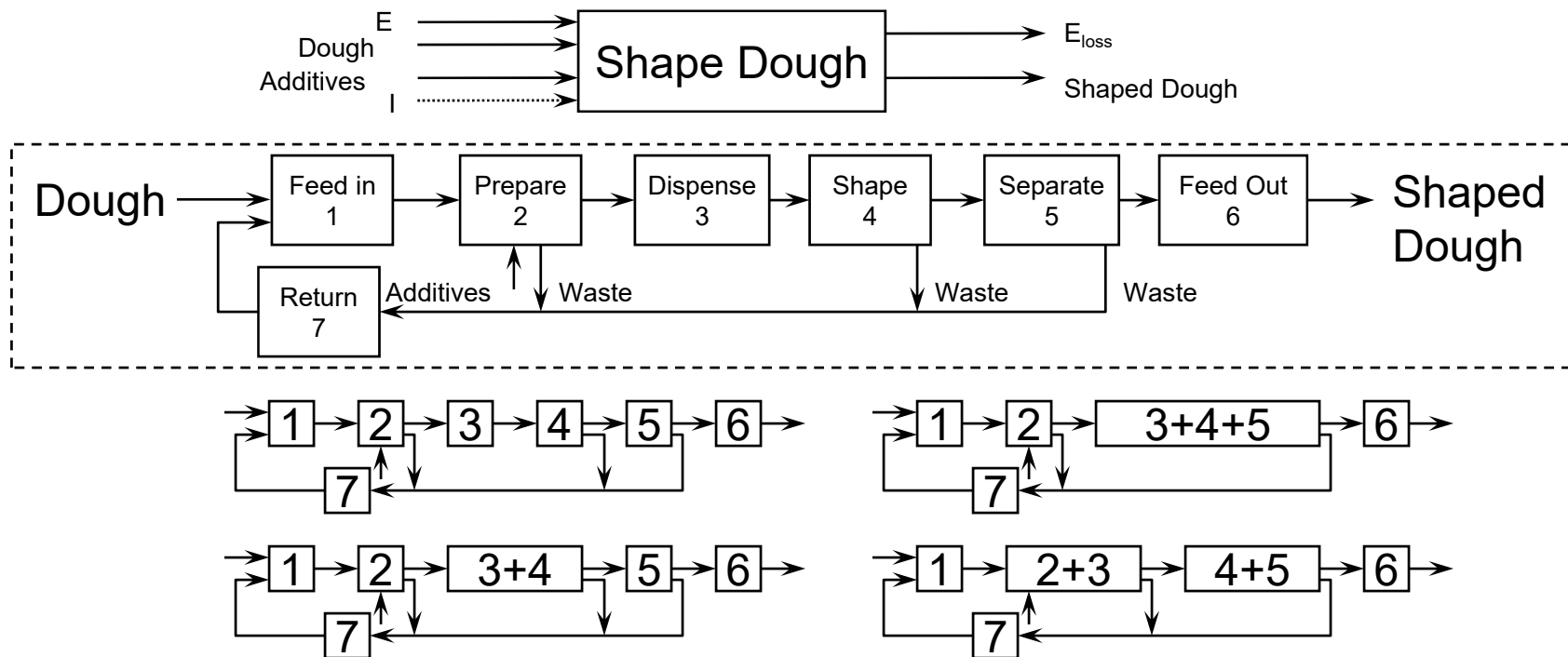
Functions & Sub-Functions for a Testing Machine



Complete Function Structure for Testing Machine

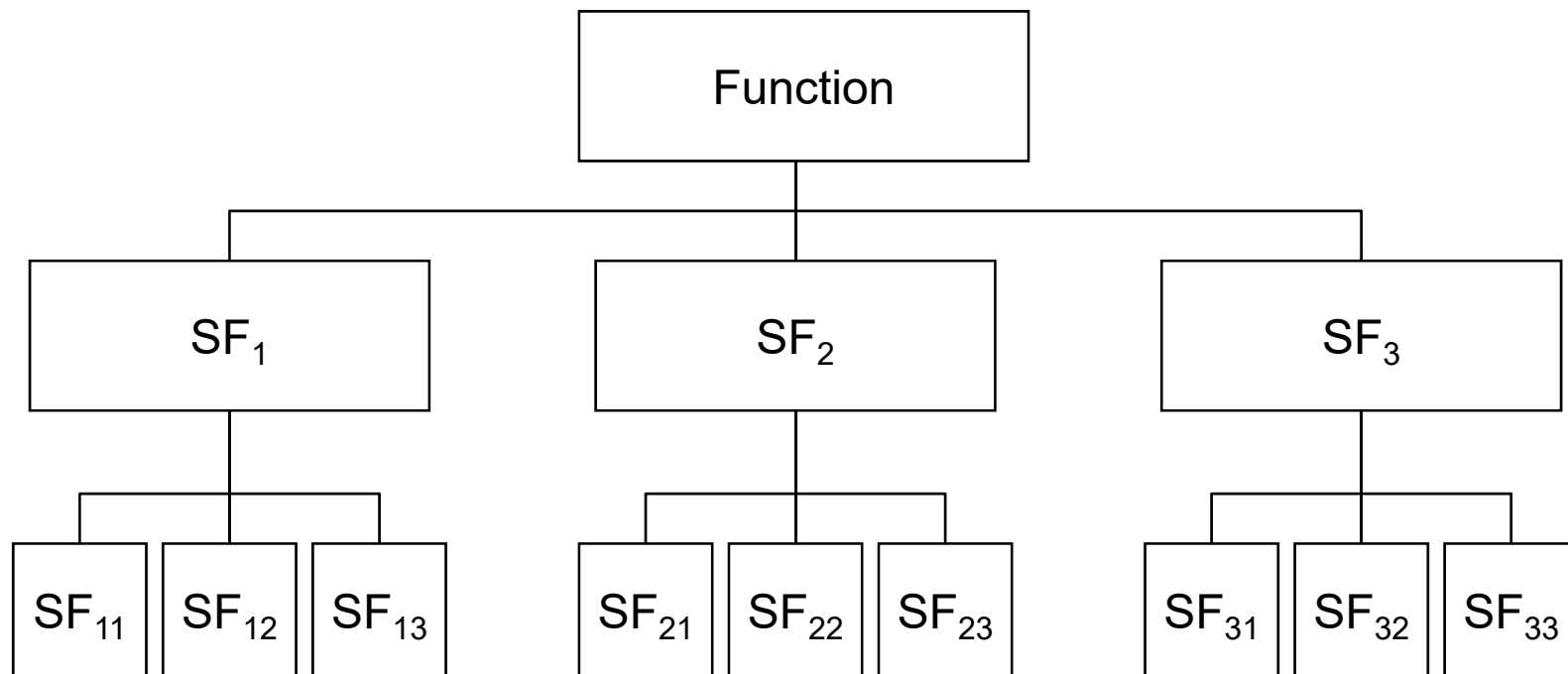


Functional Variants for Dough Shaping



Overall function and function structure variants of a dough-shaping machine for the manufacture of biscuits (in respect of the main flow only)

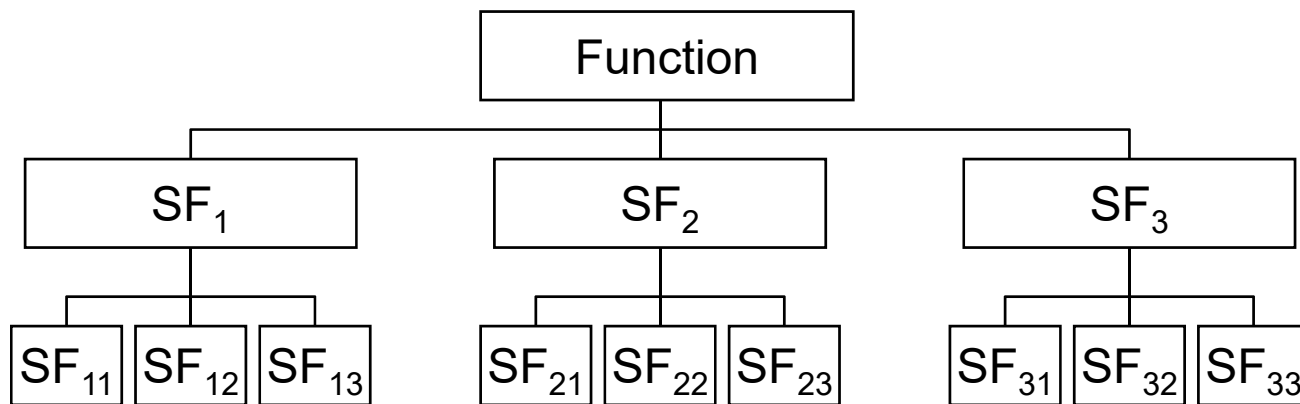
Functions & Sub-Functions



Function Table

Sub-Function \ Solution		1	2	...	j	...	m
		1	S_{11}	S_{12}		S_{1j}	
2	S_{21}	S_{22}		S_{2j}		S_{2m}	
...							
i	S_{i1}	S_{i2}		S_{ij}		S_{im}	
...							
n	S_{n1}	S_{n2}		S_{nj}		S_{nm}	

Functions & Sub-Functions



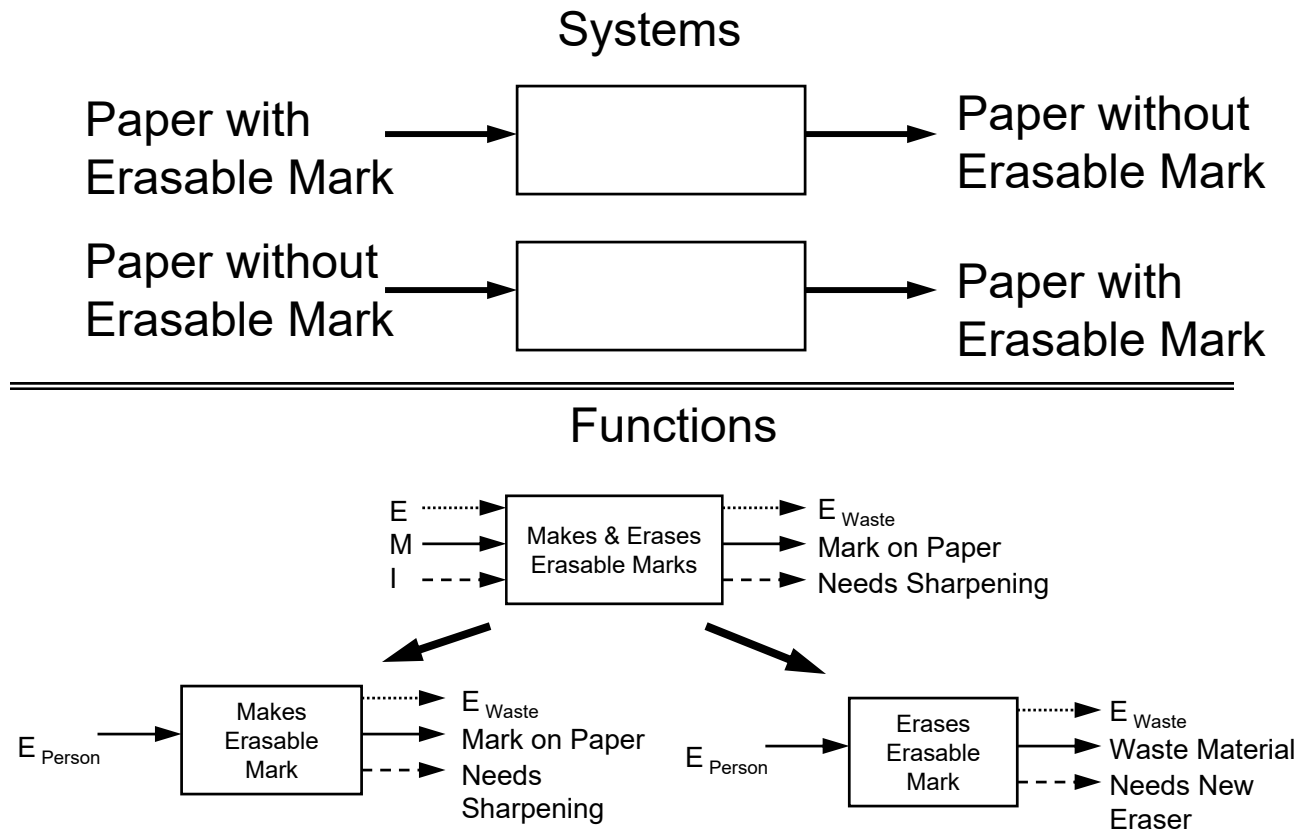
Sub-Function \ Solution		Solution					
		1	2	...	j	...	m
1	SF ₁	S ₁₁	S ₁₂	...	S _{1j}	...	S _{1m}
2	SF ₂	S ₂₁	S ₂₂	...	S _{2j}	...	S _{2m}
...							
i	SF _i	S _{i1}	S _{i2}	...	S _{ij}	...	S _{im}
...							
n	SF _n	S _{n1}	S _{n2}	...	S _{nj}	...	S _{nm}

Solution Principles

Sub-Function	Physical Effect (Independent of Solution)	Physical Principle (Sub-function & Physical Effect)	Solution Principle (Physical Principle & form Design Features)
	<p>Friction</p> <p>$F_F = \mu F_N$</p>	<p>Transfer Torque by Friction</p> <p>$F_T = F_F = \mu F_N$</p>	<p>Friction Surface</p>
	<p>Lever</p> <p>$bF_B = aF_A$</p>	<p>Amplify Muscular Force by Lever</p> <p>$F_B = F_A(a/b)$</p>	
	<p>Expansion</p> <p>$\Delta L = (\alpha)(L)(\Delta T)$</p>	<p>Close Contact by Expanding Mercury</p> <p>$\Delta L = (\alpha)(L)(\Delta T)$</p>	

Fulfilling sub-functions by solution principles built up of physical principles and form design features

Systems & Functions



Solution Principle Matrix

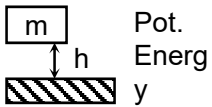
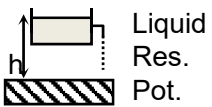
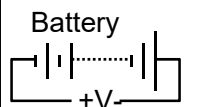

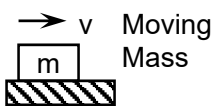
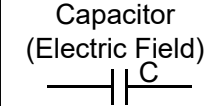


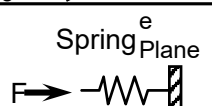
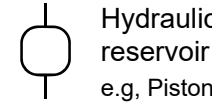
Example: Design of a Pencil

Sub-function 1: Make an Erasable Mark

Sub-function 2: Erase an Erasable Mark

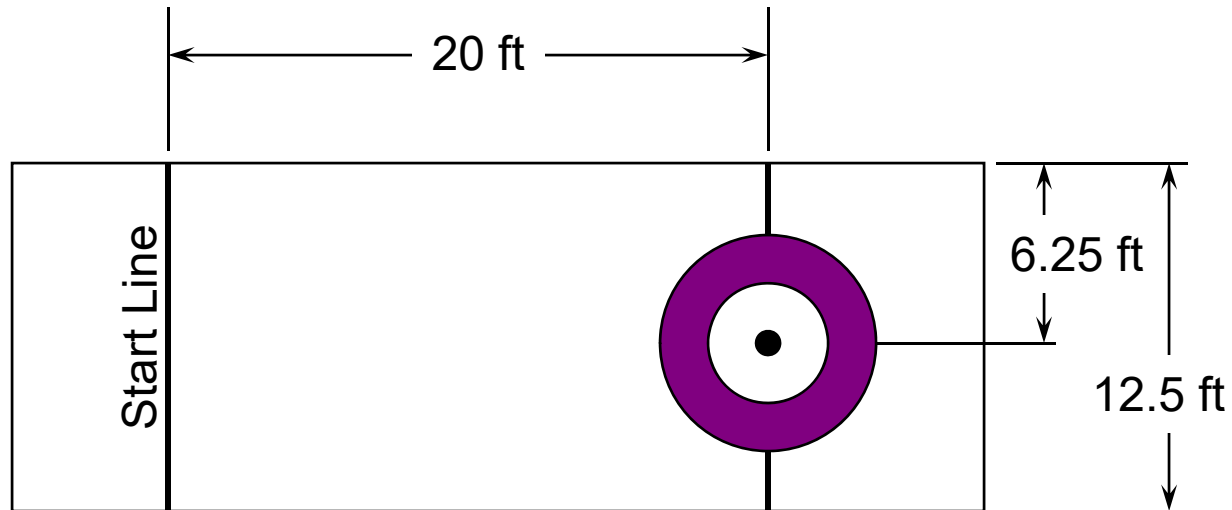
Sub-func.	Solution Principles (Idea/ Source)			
1	Idea: (Mechanical) Rub on Material	(Mechanical) Squirt Material	(Mechanical) Place Material (like Letterset)	(Chemical) Change paper composition
	Source: Standard product	Team #2	Letterset	Acid etching
1	(Chemical) Change paper color (like Litmus paper)	(Electrical) Burn paper (spark) (like old fashioned strip chart recorders)	(Electrical) Electrify Paper (glow discharge)	(Electrical) Static charge to hold mark on (like Etch-A-Sketch)
	Fisher Scientific	Team #3	Team #1	Etch-A-Sketch
1	(Thermal) Burn paper (flame)	(Thermal) Heat paper (glow discharge)	(Thermal) Melt on Mark	(Magnetic) Attach magnetic material (like refrigerator magnets)
	Team #2	Team #2	Wax seals	Gift Store
1	(Biological) Grow bacteria, fungus	(Biological) Modify (digest?) paper	(Optical) Change light properties of paper (reflectance, polarity)	(Optical) Change light (hologram)
	Team #2	BioTech Magazine	Team #2	Team #2
2	(Mechanical) Rub off Material	(Mechanical) Take off material	(Mechanical) Cover mark (like white out)	(Chemical) Change paper composition
	Standard product	Team #2	Team #1	Team #2
2	(Chemical) Change paper color (like dying fabric the same color as a stain)	(Chemical) Change mark (e.g., bleach)	(Electrical) Burn off mark (spark)	ETC.
	Team #1	Team #2	Team #2	

Different Principles to Store Energy

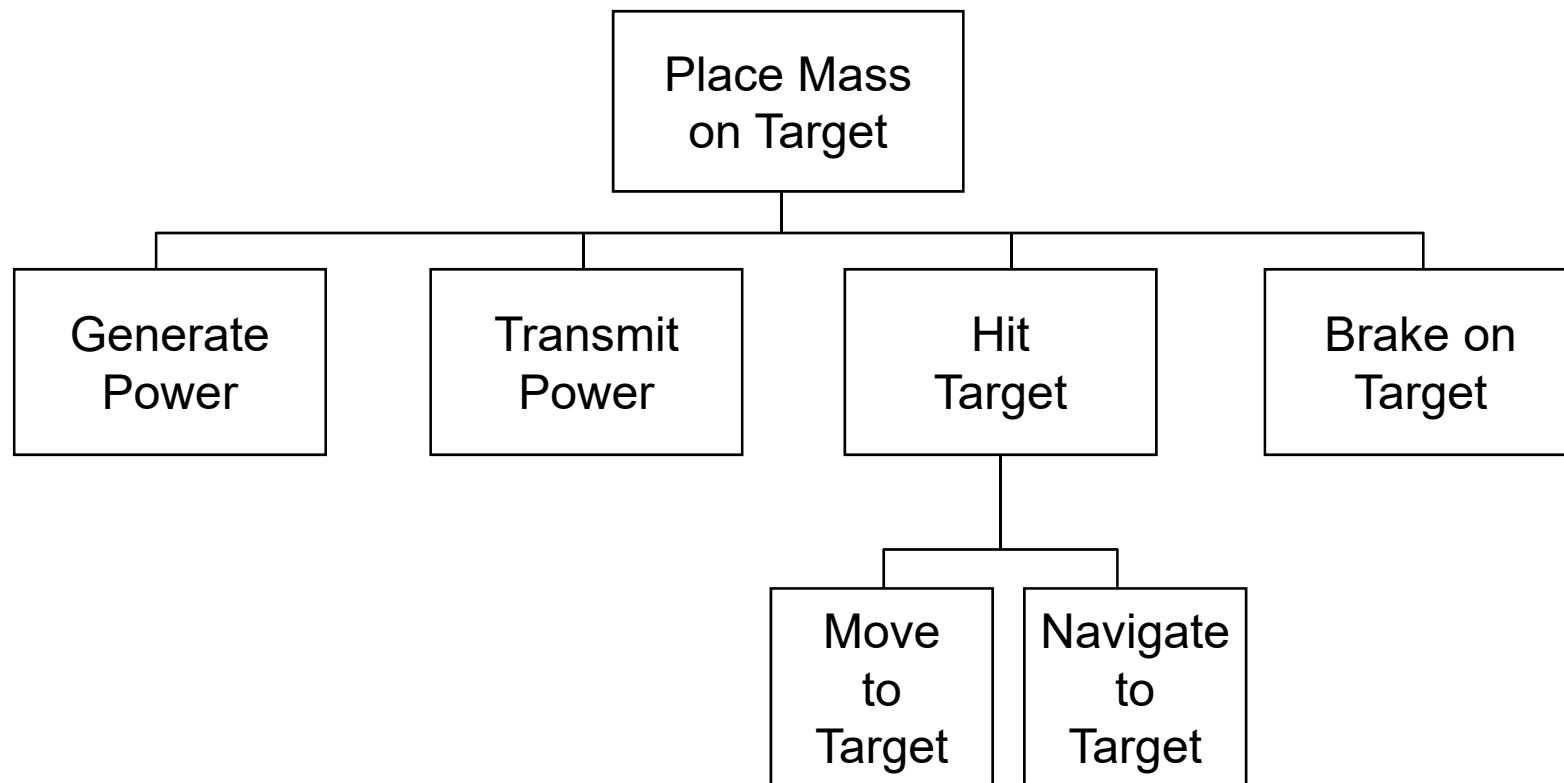
Type of Energy Working Principle	Mechanical	Hydraulic	Electrical	Thermal
1	 <p>Pot. Energ y</p>	 <p>Liquid Res. Pot.</p>	 <p>Battery +V</p>	 <p>Mass M, s, T</p>
2	 <p>Moving Mass v</p>	<p>Flowing Liquid E.</p>	 <p>Capacitor (Electric Field) C</p>	<p>Heated Liquid</p>
3	 <p>Flywheel ω J</p>			<p>Superheated Steam</p>
4	 <p>Whee on inclin ω v J</p>			
5	 <p>Spring^e Plane F</p>	<p>Other Springs Comp. Gas F</p>		
6		 <p>Hydraulic reservoir e.g, Piston</p>		

Different working principles to satisfy the function “store energy” by varying the type of energy.

An Old Competition

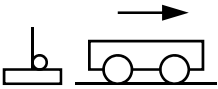
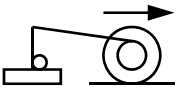
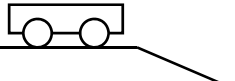

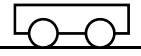
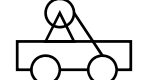
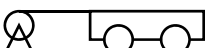
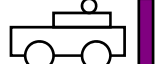

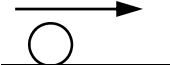
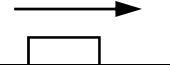





Function Tree Diagram

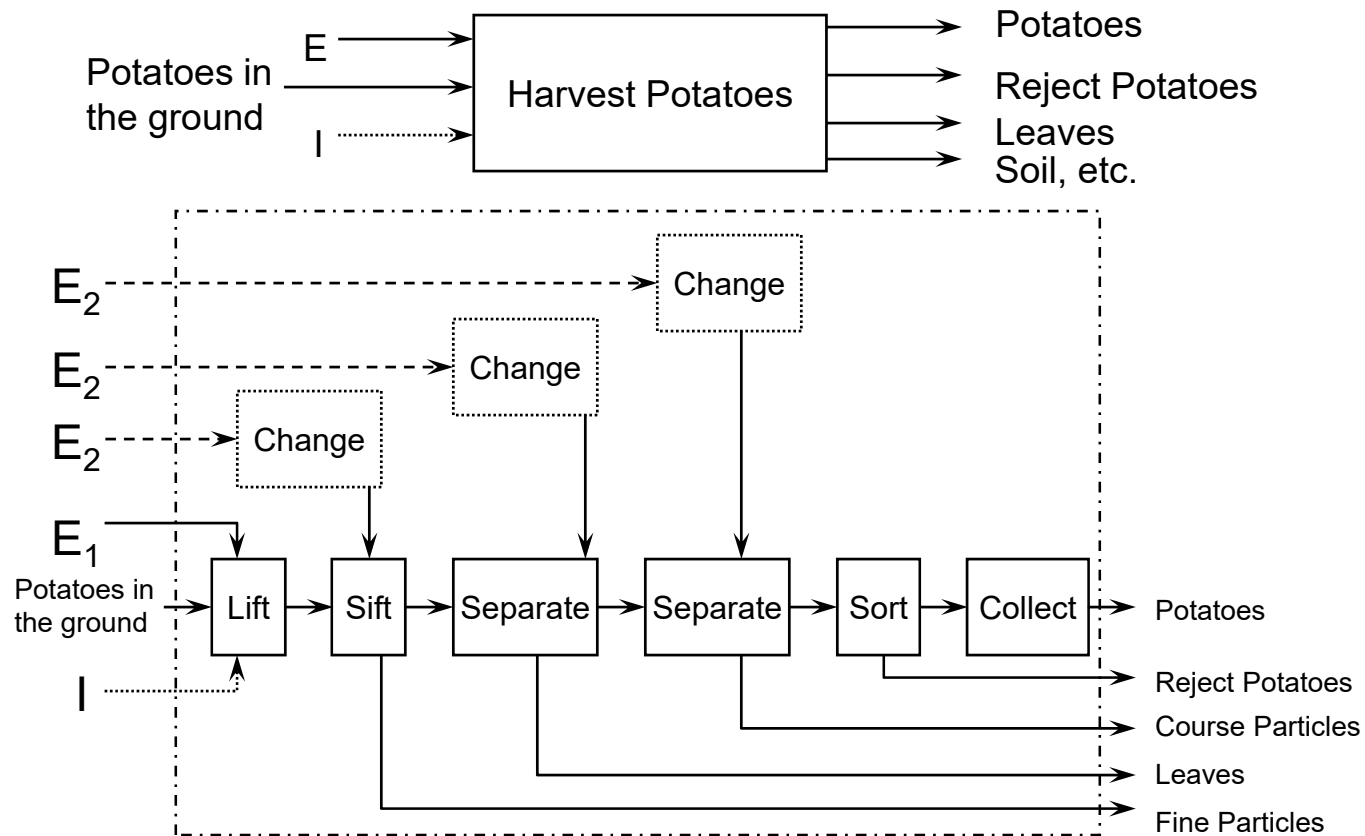


The Morphological Chart

❖ Going from concept to physical reality

Generate Power	Gravity		Mouse Traps		
Transmit Power	 <p>Car Hit by Trap</p>	 <p>Rip Cord Effect</p>	 <p>Ramp</p>	 <p>Catapult</p>	
Brake on Target	 <p>Friction</p>	 <p>String Break</p>	 <p>Anchor</p>	 <p>Rubber Stopper</p>	 <p>Weighted Skid</p>
Move to Target	 <p>Rolling</p>	 <p>Sliding</p>	 <p>Projectile Launch</p>		
Navigate to Target	 <p>Equal Size Wheels</p>	 <p>Larger Front Wheels</p>			

Example Harvest Potatoes



The Potato Harvester

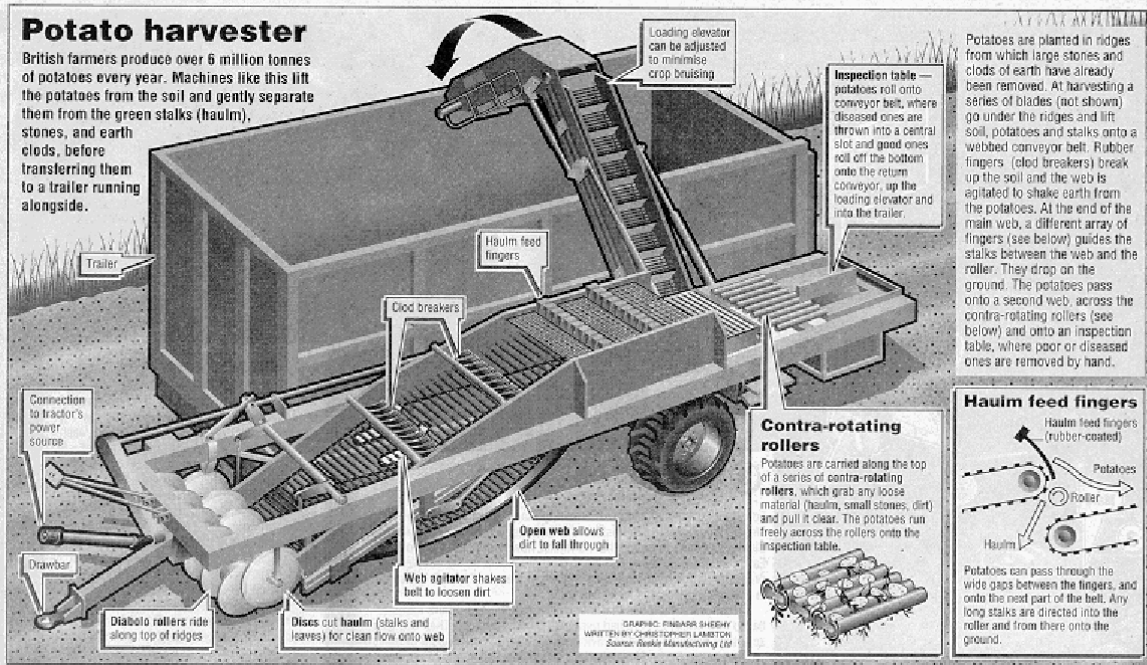
12 Resources

HOW IT WORKS

Guardian Education Tuesday March 19 1996

Potato harvester

British farmers produce over 6 million tonnes of potatoes every year. Machines like this lift the potatoes from the soil and gently separate them from the green stalks (haulm), stones, and earth clods, before transferring them to a trailer running alongside.



Potatoes are planted in ridges from which large stones and clods of earth have already been removed. At harvesting a series of blades (not shown) go under the ridges and lift soil, potatoes and stalks onto a webbed conveyor belt. Rubber fingers (clod breakers) break up the soil and the web is agitated to shake earth from the potatoes. At the end of the main web, a different array of fingers (see below) guides the stalks between the web and the roller. They drop on the ground. The potatoes pass onto a second web, across the contra-rotating rollers (see below) and onto an inspection table, where poor or diseased ones are removed by hand.

Contra-rotating rollers
Potatoes are carried along the top of a series of **contra-rotating rollers**, which grab any loose material (haulm, small stones, dirt) and pull it clear. The potatoes run freely across the rollers onto the inspection table.

Haulm feed fingers
Haulm feed fingers (rubber-coated) guide the stalks between the rollers and onto the rest part of the belt. Any long stalks are directed into the roller and from there onto the ground.

GRAPHIC: RINDARA SHEEHY
WRITTEN BY CHRISTOPHER LAMINGTON
SOURCE: BAKER MANUFACTURING CO.

Combining Solution Principles

Sub-Functions	\Solutions	1	2	...	j	...	m
1	F_1	S_{11}	S_{12}		S_{1j}		S_{1m}
2	F_2	S_{21}	S_{22}		S_{2j}		S_{2m}
\vdots	\vdots	\vdots	\vdots		\vdots		\vdots
i	F_i		S_{i2}		S_{ij}		S_{im}
\vdots	\vdots	\vdots	\vdots		\vdots		\vdots
n	F_n	S_{n1}	S_{n2}		S_{nj}		S_{nm}

1 2 Combination of Principles

Combination 1: $S_{11} + S_{21} + \dots + S_{n1}$

Combination 2: $S_{12} + S_{22} + \dots + S_{n2}$

The Morph Chart

Solutions		1				2				3				4				...					
		Sub-functions				1				2				3				4				...	
1	Lift																						
2	Sift																						
3	Separate leaves																						
4	Separate stones																						
5	Sort potatoes	by hand				by friction (inclined plane)				checksize (hole gauge)				check mass (weighing)									
6	Collect	Tipping hopper				Conveyor				Sack-filling device													

Combination of principles

Figure 5.42. Combination of principles for designing a potato harvesting machine in accordance with the overall function structure shown in Figure 5.16