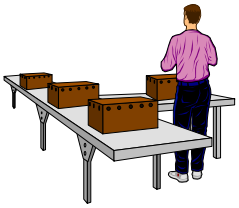
Lesson 10
Design of Work Systems

involves job design, work measurement, establishment of time standards and worker compensation



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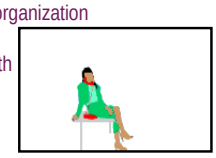
Job Design

Job Design involves specifying the content and methods of jobs. The *goal* is to create a work system that is productive and efficient.

To be successful, job design must:

. be carried out by personnel with proper training and background
. consistent with the goals of the organization
. in written form
. understood and agreed to by both management and employees



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Decisions In Job Design

Job Structure

Who Mental and physical characteristics of the work force	**When** Time of day; time of occurrence in the work flow
What Tasks to be performed	**Why** Organizational rationale for the job; objectives and motivation of the worker
Where Geographic locale of the organization; location of work areas	**How** Method of performance and motivation

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Job Design

A properly designed job

. Improves efficiency through analysis of the job's work elements
. Improves productivity through consideration of technical and human factors
. Increases the quality of the final product or service
. Increases worker satisfaction
. Improves the bottom line

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Evolution of Job Design

1900s to 1960s - Scientific Management/Assembly Lines	1970s to 1990s - Employee Participation & Involvement
Task specialization	Horizontal job enlargement
Minimal worker skills	Vertical job enlargement
Repetition	Extensive job training
Minimal job training	Job control
Mass production	Training & education
Piece-rate wages	Job rotation
Time as efficiency	Higher skill levels
Minimal job responsibility	Team problem solving
Tight supervisory control	Focus on quality

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Recent Trends In Job Design

Some of the recent trends in job design include:

. Quality control as part of the worker's job
. Increased skill & ability levels - cross-training workers to perform multi-skilled jobs - education & training viewed as long-term investments
. Employee involvement (responsibility & empowerment) and team approaches to designing and organizing work (job and task flexibility
. Involving ordinary workers through telecommunication networks and computers
. Extensive use of temporary workers
. Technology & automation of heavy manual work
. Organizational commitment to providing meaningful and rewarding jobs (content & remuneration) for all employees

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Job Design

Two major approaches to job design: *Efficiency*, *Behavioral*

Efficiency - emphasizes systematic, logical approach

Behavioral - emphasizes the satisfaction of wants and needs

Considerations in Job Design

- Specialization
- Behavioral Approaches to Job Design
- Teams
- Methods Analysis
- Motion Study
- Working conditions
- Incentive pay plans

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Specialization

Specialization - jobs that have a very narrow scope (welder, plumber, medical technician, real estate lawyer, assembly line worker)

Advantages

For Management	*For Labor*
simplifies training	low education requirements
high productivity	minimum responsibilities
low wage costs	little mental effort required

Disadvantages

For Management	*For Labor*
difficult to motivate quality	monotonous work
worker dissatisfaction	limited advancement
little control over work	little self-fulfillment

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Behavioral Approaches

Behavioral Approaches to Job Design deal with improving the worker's attitude toward their jobs. Over the last few years advancement has been made to empower employees by giving the worker more responsibility for their work.

Theory X - workers do not like to work and have to be controlled rewarded, punished) to get them to do a good job.

Theory Y - workers who enjoy their work will become committed to doing a good job.

Theory Z - (William Ouchi) workers who are empowered to control their work (solve problems, participate in decisions) will develop an ownership attitude.

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Behavioral Approaches

Job Enlargement - giving a worker a larger portion of the total task by increasing the variety of skills

Job Rotation - workers periodically exchange jobs

Job Enrichment - increasing responsibility for planning and coordination tasks along with other responsibilities

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Teams

Teams - responsibility for the problems are shared among team members - sometimes difficult to implement because of
- . management issues (feeling threatened of losing control)
- . people issues (getting along with each other)

Self-directed teams - empowered to make changes in their work environment (e.g. workers doing the work are more knowledgeable)

Advantages
- . higher quality
- . higher level of motivation
- . higher level of job satisfaction leading to lower absenteeism, less turnover and lower costs for training new workers

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Successful Teams

The more successful teams have
- . Common commitment to overarching purpose
- . Shared leadership
- . Individual and collective performance judgement
- . Open-ended discussion
- . Team works together
- . Meaningful, well-defined direction
- . Positive environment
- . Clear rules for behavior
- . Early successes
- . Fresh ideas from outside the team
- . Spend lots of time together
- . Positive reinforcement

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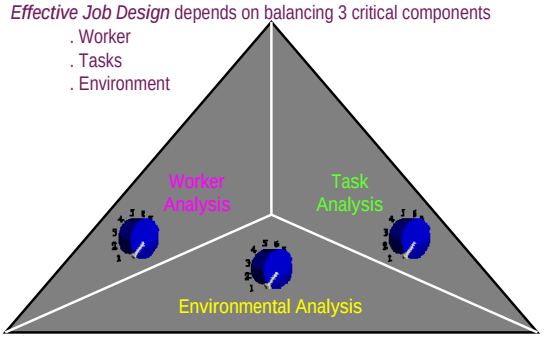
Components Of Job Design

Effective Job Design depends on balancing 3 critical components

. Worker
. Tasks
. Environment



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Worker Analysis

The worker analysis requires a detailed understanding the skills necessary to perform a set of tasks (to ensure that the right workers are assigned to the right jobs). It involves an assessment of

. Capabilities (skill level, physical abilities, motivation)
. Mental stress
. Boredom
. Number of workers required
. Level of responsibility
. Monitoring level
. Quality responsibility
. Empowerment level
. Evaluation methodology

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Task Analysis

The task analysis consists of a detailed description of

. Tasks – where are they performed (fixed station, interaction with equipment, interaction with other people)
. Task steps - sequence
. Function of tasks
. Frequency of tasks
. Criticality of tasks
. Task duration(s)
. Relationship with other jobs/tasks
. Error possibilities
. Requirements for performance, information, control, equipment

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Environmental Analysis

The environmental analysis addresses physical attributes of the workplace because they can have a dramatic affect on worker productivity

. Work place location
. Process location
. Temperature and humidity
. Lighting
. Ventilation
. Safety
. Logistics
. Space requirements
. Noise
. Vibration

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KISS Principle Of Job Design

Human Element
. Work - simplified, rhythmic & symmetric
. Hand/arm motions - coordinated & simultaneous
. Employ full extent of physical capabilities
. Conserve energy - use machines, minimize distances
. Tasks - simple, minimal eye contact & muscular effort, no unnecessary motions, delays or idleness

Workspace Element
. Tools, material, equipment - designated, easily accessible
. Seating & work area - comfortable & healthy

Equipment Element
. Equipment & mechanized tools enhance worker abilities
. Use foot-operated equipment to relieve hand/arm stress
. Construct & arrange equipment to fit worker use

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Methods Analysis

Methods Analysis - focuses on how a job (existing or new) is done beginning with general details about a job then focusing on the specific tasks in the job

The need for methods analysis comes from:
. Changes in tools and/or equipment
. New products or changes in existing products
. Changes in materials or procedures
. Government regulations
. Contractual agreements
. Accidents
. Quality problems

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Methods Analysis

The *methods analysis procedure* involves

. Gathering all pertinent information (tools, equipment, materials, etc.) for the operation to be studied
. Discuss the job with the people who do it
. Discuss the job with the people who supervise it
. Study and use process charts to document the present method the job is done
. Analyze the job
. Propose new methods
. Install new methods
. Follow up installation to assure improvements have been achieved

A *process flow chart* is very useful to document the tasks and flow of work in a job.

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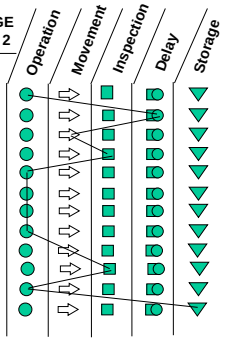
Process Flow Analysis

FLOW PROCESS CHART
Job Requisition of petty cash

ANALYST D. Kolb | **PAGE** 1 of 2

Details of Method

Requisition made by department head
Put in "pick-up" basket
To accounting department
Account and signature verified
Amount approved by treasurer
Amount counted by cashier
Amount recorded by bookkeeper
Petty cash sealed in envelope
Petty cash carried to department
Petty cash checked against requisition
Receipt signed
Petty cash stored in safety box



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Motion Study

Motion Study - is the systematic study of the human motions used to perform an operation - the purpose is to eliminate unnecessary motions used to perform an operation. It is very effective in improving worker productivity and lowering costs

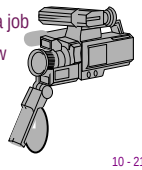
Motion Study Techniques

Motion study principles - guidelines for designing motion-efficient work procedures

Analysis of therblings - basic elemental motions in a job

Micro-motion study - use of motion pictures and slow motion to study motions that otherwise would be too rapid to analyze

Charts



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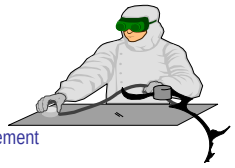
Work Measurement

Work Measurement - involves determining how long it should take to do a job. *Time Standards* - represent the amount of time it should take a qualified worker to complete a specified task, working at a sustainable rate, using given methods, tools, equipment, raw materials, and workplace environment (layout, conditions)

Job Times are important for:

. Manpower planning
. Estimating labor costs
. Planning and scheduling
. Budgeting
. Providing benchmarks for improvement
. Motivating the work force
. Designing pay incentive plans



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Work Measurement

The most common ways to develop time standards for tasks:

. *Stopwatch time study* - development of a time standard by observing the time it takes to perform a job over several observation periods
. *Historical times*
. *Predetermined data* (many industry associations or consultants have time standard information)
. *Work Sampling*

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Job Standards – Don't Reinvent The Wheel

Standard Elemental Times are time standards derived from the firm's historical time data. When setting a new job standard there is no reason to "reinvent the wheel". *Check the files to determine job elements that have been "measured" and apply these rates appropriately.*

Predetermined Time Standards are available in many instances through industry publications, associations, industrial engineering associations. A commonly used system is methods-time management (*MTM*)tables created by the Methods Engineering Council.

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Time Study

The steps in a time study are:

. Identify the task
. Inform the worker that he/she is being studied
. Time the job over several observation periods (cycles)
. Rate the worker's performance
. Compute the time standard

The *number of cycles* that must be timed are a function of :

. Variability of the observed times
. Desired accuracy
. Desired level of confidence for the estimated job time

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Time Study

The *number of cycles* that should be timed (to within a desired % accuracy) can be calculated by:

$$n = \left(\frac{Zs}{a\overline{X}}\right)^2 \text{ where}$$

Z = number of normal standard deviations for desired confidence
s = sample standard deviaiton
a = desired accuracy percentage
$\overline{X}$ = sample mean

Typical Z Values	
Desired Confidence Level %	Value
90	1.65
95	1.96
95.5	2.00
98	2.33
99	2.58

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Time Study - Example

Example 1a: A time study analyst wants to estimate the time required to perform a certain job. A preliminary study yielded a mean of 6.4 minutes with a standard deviation of 2.1 minutes. For a desired confidence of 95% how many cycles must be observed if the desired accuracy is within 10% of the mean.

$$n = \left(\frac{Zs}{a\overline{X}}\right)^2 = \left(\frac{1.96(2.1)}{.10(6.4)}\right)^2$$

$$= 41.36 \text{ rounded up to } 42$$

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Time Study

An *alternate calculation* for the *number of cycles*, when the desired accuracy is stated as a an actual amount (e.g. within 1 minute of the true mean) is:

$$n = \left(\frac{Zs}{e}\right)^2 \text{ where}$$

e = accuracy or maximum acceptable error

Example 1b: For a desired confidence of 95% how many cycles must be observed if the desired accuracy is within one-half minute?

$$n = \left(\frac{Zs}{e}\right)^2 = \left(\frac{1.96(2.1)}{.5}\right)^2$$

$$= 67.77 \text{ rounded up to } 68$$

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Job Standard Time

Development of a *job standard time* involves computation of *3 times:*

- *Observed time* - the average of the observed times
- *Normal time* - the observed time adjusted for worker performance
- *Standard time* - the length of time a worker should take to perform a job if there are no delays or interruptions

The *observed time (OT)* is calculated by:

$$OT = \frac{\sum x_i}{n} \text{ where}$$

OT = observed time

x_i = ith recorded time

n = total number of recorded times

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Job Standard Time

If a *job performance rating has been determined* for an entire job, the *normal time (NT)* is calculated by:

$$NT = OT * PR_{job}$$

NT = normal time

PR_{job} = performance rating for the entire job

If a *job performance rating has not been determined* for an entire job, the *normal time (NT)* is calculated by:

$$NT = \sum\left(\bar{x}_i * PR_i\right) \quad \text{where}$$

$\bar{x}_i$ = average time for job element i

PR_i = performance rating for job element i

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Job Standard Time

The reason for the *job adjustment factor* is that the worker being observed may be working at a rate different from the normal rate (working at a deliberately slow rate, natural abilities differ from the norm, working at a rate to impress the observer). Thus the *observed time* is *adjusted* by this factor to yield a more accurate work pace.

performance rating = 1.0	indicates the worker is working at a normal rate
performance rating = .90	indicates the worker is working at 90% of a normal rate
performance rating = 1.10	indicates that the worker is working 10% faster than a normal rate

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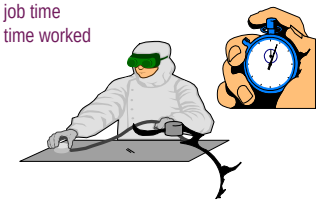
Job Standard Time

The *standard time (ST)* is the length of time a worker should take to perform a job if there are no delays or interruptions. An *allowance factor (AF)* is used to *adjust the normal time* to allow for delays, interruptions or breaks.

The *standard time (ST)* is calculated by one of the following methods:

. Allowance factor for job time
. Allowance factor for time worked



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Job Standard Time

If the *allowance factor has been determined for the job time* the *standard time (ST)* is calculated by:

$$ST = NT * AF_{job}$$

$$AF_{job} = \text{allowance factor for delays, interruptions, breaks}$$

The *allowance factor* based on *job time* is calculated by:

$$AF_{job} = 1 + A_{job}$$

$$A_{job} = \text{allowance percentage based on job time}$$

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Job Standard Time

If the *allowance factor has been determined for the time worked (day)* the *standard time (ST)* is calculated by:

$$ST = NT * AF_{day}$$

AF_{day} = allowance factor for delays, interruptions, breaks

The *allowance factor* based on *time worked (day)* is calculated by:

$$AF_{day} = \frac{1}{1 - A_{day}}$$

A_{day} = allowance percentage based on workday

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Job Standard Time - Example

Example 3: A time study of an assembly operation yielded the following observed times for one element of the job for which the analyst gave a performance rating of 1.13. Using an allowance of 20% of job time, determine the appropriate standard time for this operation.

ith observation	Time (minutes)
1	1.12
2	1.15
3	1.16
4	1.12
5	1.15
6	1.18
7	1.14
8	1.14
9	1.19
Total	10.35

$PR_{job} = 1.13$ (job performance rating)

$A_{job} = .20$ (allowance for job time)

$n = 9$ (total number of recorded times)

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Job Standard Time - Example

To calculate the standard time for this operation we must calculate the three times OT, NT and then ST

$$OT = \frac{\sum x_i}{n} = \frac{10.35}{9} = 1.15 \text{ minutes}$$

$$NT = OT * PR_{job} = 1.15 * 1.13 = 1.30 \text{ minutes}$$

$$ST = NT * AF_{job} = NT * (1 + A_{job}) = 1.30 * 1.20 = 1.56 \text{ minutes}$$

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Work Sampling

Work Sampling is a technique for estimating the proportion of time that a worker or machine spends on various activities. It involves observation of a worker or machine where the resulting data are counts of the number of time each activity or non-activity is performed. (e.g. secretary typing, talking, filing, etc)

The primary use of work sampling studies is for:

. *Ratio-delay information* - the percentage of a workers time involved in unavoidable delays or interruptions

. *Analysis of non-repetitive jobs* (e.g. maintenance work, administrative work, etc.)

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Work Sampling

Work sampling develops a *sampling proportion* $\hat{p}$ which estimates the *true proportion* p of time a worker spends on a job within some *allowable error* e .

$$\hat{p} = \frac{\text{(Observed Count)}}{n} \quad n = \text{sample size}$$

For large samples (20 or so) the *maximum error* can be calculated by the following formula:

$$e = z\sqrt{\frac{\hat{p}(1-\hat{p})}{n}} \text{ where}$$

z = standard deviations to achieve the desired confidence

n = sample size

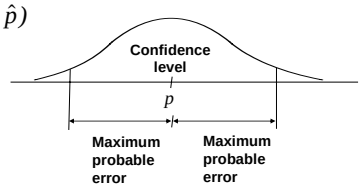
10 - 38

Work Sampling

In the instance where the confidence level and maximum allowable error are specified the following formula (which is a mathematical simplification of the previous one) can be used to *determine the sample size* necessary to obtain the desired results:

$$n = \left(\frac{z}{e}\right)^2 \hat{p}(1-\hat{p})$$

The concept in work sampling is the same as that learned in DSCI 232



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Work Sampling - Example

Example 4: The manager of a small supermarket chain wants to estimate the proportion of time that stock clerks spend making price changes on previously marked merchandise. The manager wants a 98% confidence level such that the resulting error will be within 5% of the true value. What sample size should be used?

Typical Z Values	
Desired Confidence Level %	Value
90	1.65
95	1.96
95.5	2.00
98	2.33
99	2.58

$e = .05 \quad z = 2.33$

$$n = \left(\frac{z}{e}\right)^2 \hat{p}(1-\hat{p})$$

We do not have an estimate of proportion, so what do we do?

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Work Sampling - Example

We must first start with a *proportion estimate*, let's say

$\hat{p} = .50$

Now we can use the formula to calculate the number of observations we must make.

$$n = \left(\frac{z}{e}\right)^2 \hat{p}(1-\hat{p}) = \left(\frac{2.33}{.05}\right)^2 *.5(1-.5) = 542.89 \text{ or } 543$$

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Work Sampling - Example

Suppose that after 20 observations we notice that the stock clerks only changed prices 2 times. At that time we revise our proportion estimate and recalculate ***n***.

$$\hat{p} = \frac{2}{20} = .10$$

$$n = \left(\frac{z}{e}\right)^2 \hat{p}(1-\hat{p}) = \left(\frac{2.33}{.05}\right)^2 *.1(1-.1) = 195.44 \text{ or } 196$$

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Work Sampling - Example

Suppose that after 80 more observations (100 total) we notice that the stock clerks only changed prices 11 times. At that time we revise our proportion estimate and recalculate ***n***.

$$\hat{p} = \frac{11}{100} = .11$$

$$n = \left(\frac{z}{e}\right)^2 \hat{p}(1-\hat{p}) = \left(\frac{2.33}{.05}\right)^2 *.11(1-.11) = 212.60 \text{ or } 213$$

The manager might want to make an additional check before settling on a final value of ***n***.

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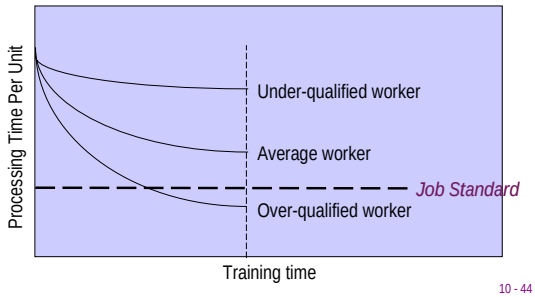
Learning Curve

Job standard times (whether developed using time studies or work sampling) are used to develop performance expectations. These can be displayed in the form of a *learning curve*.



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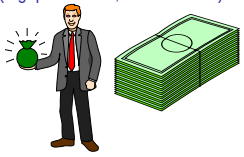
Compensation

. too little may make it hard to attract competent workers
. too much may limit profitability

Two basic systems for compensating employees
. *Time-based systems* - compensation based on time worked (e.g. hourly pay, straight salary)
. *Output-based (incentive) systems* – compensation based on output produced (e.g. piece rates, commissions)



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Compensation

Financial incentives can be based on

- . Individual and Small-Group Plans
  - .. Output measures
  - .. Quality measures
  - .. Productivity measures
  - .. Pay for knowledge
- . Organization-wide Plans
  - .. Profit sharing
  - .. Gain-sharing
    - - Bonus based on controllable costs or units of output
    - - Involve participative management

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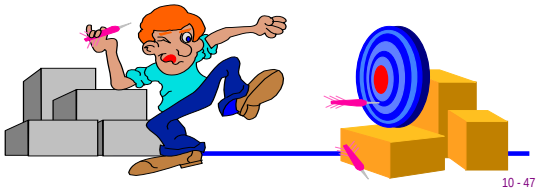
Compensation

Incentive Systems should be:

- . Accurate
- . Easy to apply
- . Consistent
- . Easy to understand
- . Fair



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Management Compensation

May consider *many dimension of performance*

- . Customer Service
- . Quality
- . Performance

Executive management compensation is usually tied directly to the performance of the Company or Division for which he/she is responsible. (e.g. Earnings per share, profitability, growth, etc.)

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Homework

Read and understand all material in the chapter.

Discussion and Review Questions

Recreate and understand all classroom examples

Exercises on chapter web page

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