AE 308: Control Theory
&
AE 775: System Modelling, Dynamics & Control

Venue: **LH 302**
Slot: **8 (Monday & Thursday 1400-1525)**

Instructor: **Ashok Joshi**

Motivation for the Course

All physical systems **exhibit dynamic** characteristics, which have impact on their **overall behaviour** in the presence of **time dependent** inputs.

Therefore, during the **design process,** efforts are made to **achieve a desirable** dynamic response under **varied operating** conditions.

However, as it is **not possible** to achieve desirable dynamic **behaviour for all** possible conditions through design, we need to **ensure this** during actual operation.

Motivation for the Course

Control discipline is the **enabler** which provides **tools** to achieve the desired **behaviour** during operation**.**

However, for this purpose, firstly, it is necessary to **capture** relevant **features** of the physical system and **study** these in a **simulated** environment.

Secondly, we need a **methodology** to ensure that the **deficiency,** if any, is **compensated**.

Present course **aims** to address **modelling, dynamic analysis & control** of engineering systems.

Evolution of Control

Control is an integral part of most **engineering systems** and has **matured** over the last **100 years.**

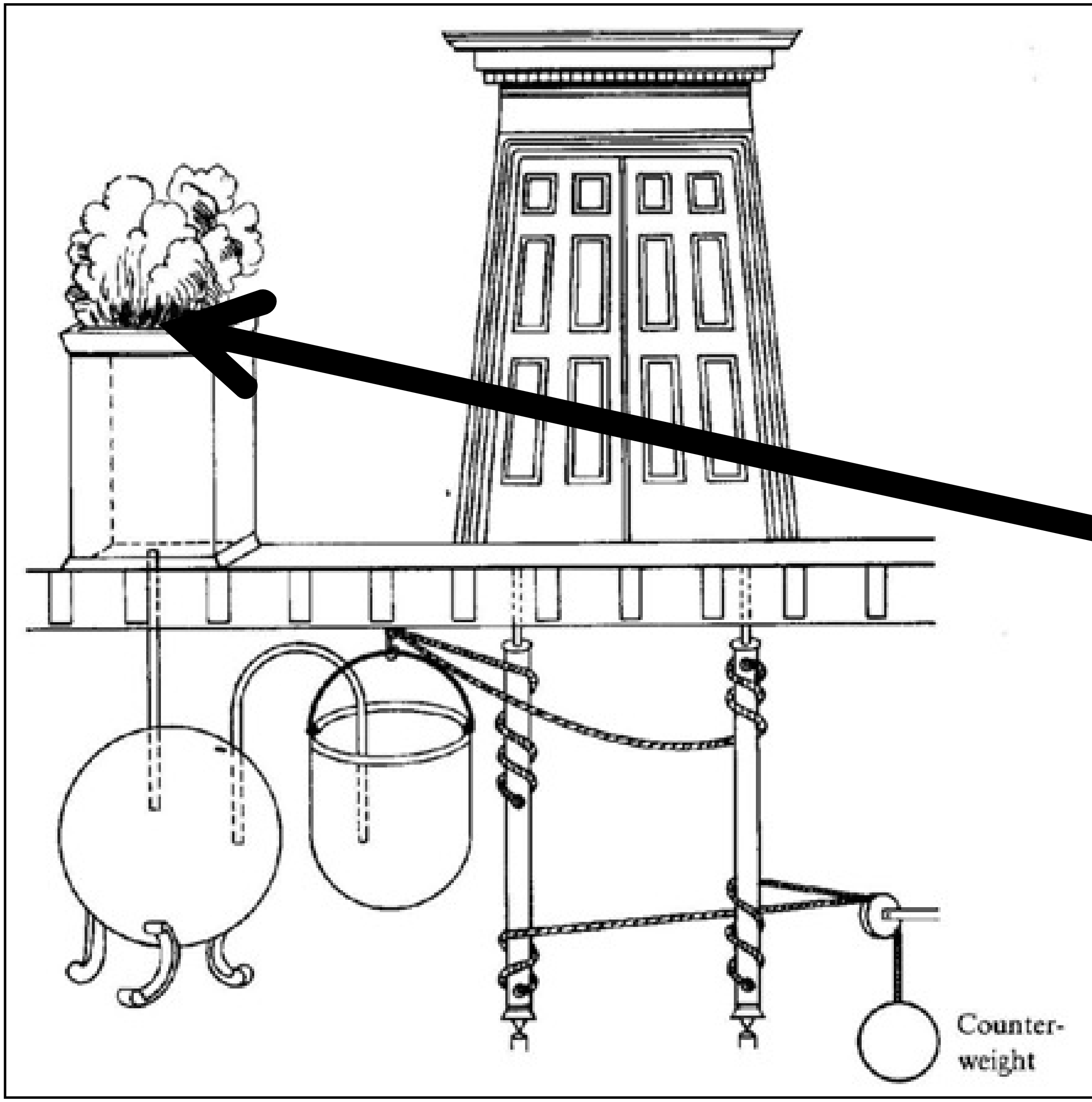
In **early 1900s**, control was used in various **industrial processes** e.g. chemicals, petroleum, steam power etc., and, thus, was called **process control**.

During this period, most **control solutions** were based on **intuitive** understanding / **experimental** verification.

Control in **mechanical systems** formally began in **1950s** which saw development of theory of **servomechanism**.

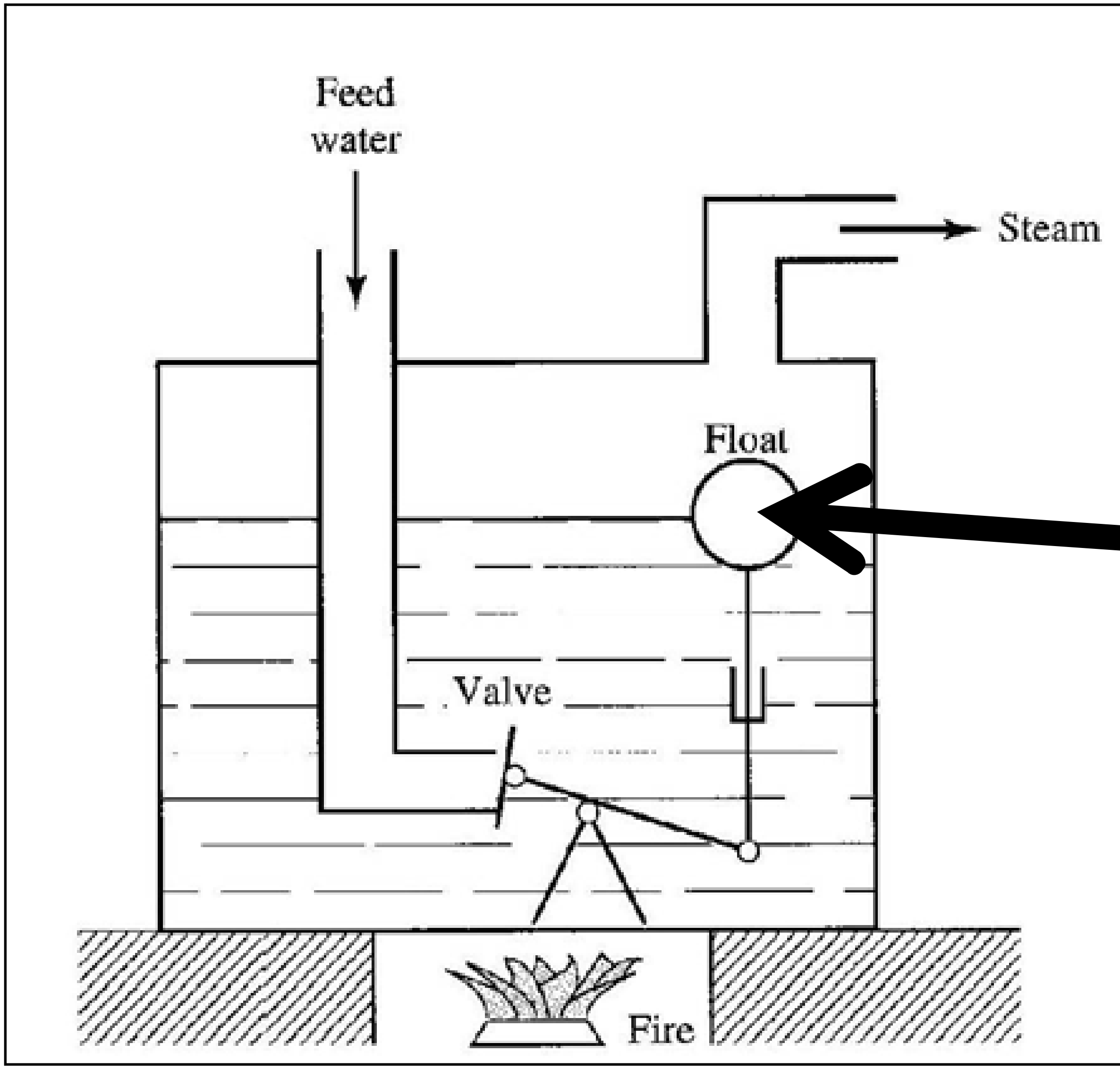
However, **control concepts** have existed **long before.**

Medieval Control Systems



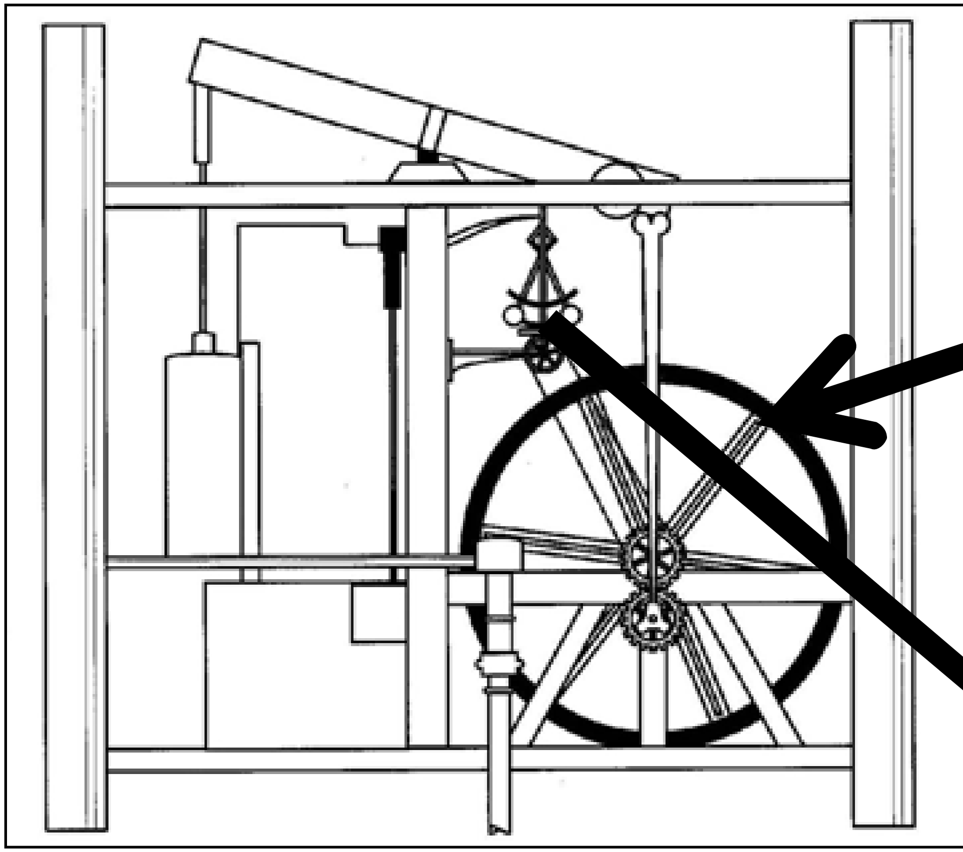
Lighting of fire on the altar was the command given for the doors to open. (***Hero's device for opening the door of temples in Greece, 1st Century A.D.***)

Early Control Concepts

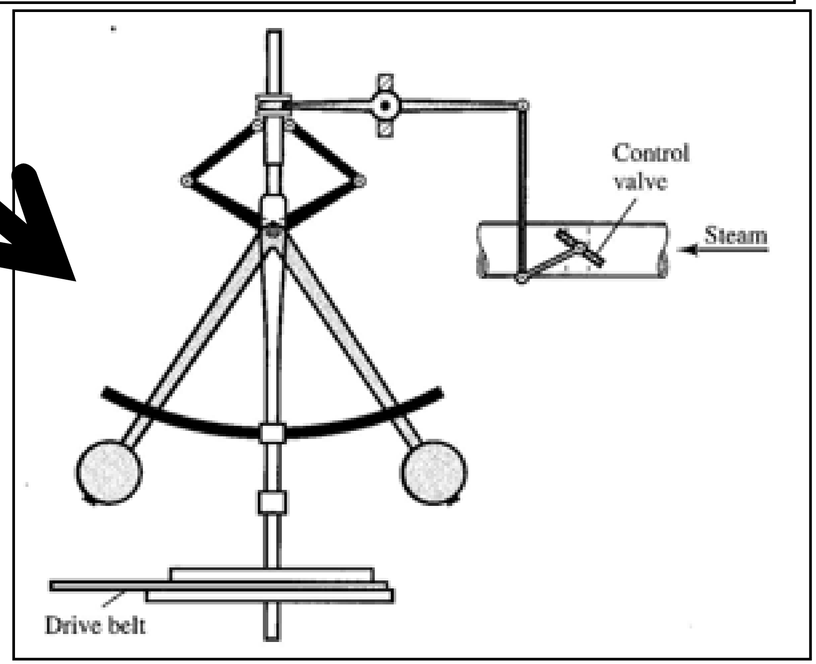


A **rise in water level** would close the valve and **stop the supply** of water into tank. (***Ivan Polzonov, engineer in coal mines in Siberia, 1763 – 1766***)

Control as Regulation



Application of **governor** to control steam **engine RPM** was an innovative breakthrough in control. (***James Watt & Willard Gibbs 17th / 18th century***)



Importance of the Subject

Control discipline is applicable to **all domains** of engineering, and is **particularly critical** to the **successful** functioning of **aerospace** systems.

It also provides a **structured methodology** to achieve desired behaviour, through application of **simple concepts.**

Lastly, **control concepts** can also help in **innovations** in existing systems. (Autonomous **cars, UAVs** ….)

Objectives of the Course

To provide exposure to techniques/methodologies for creating **good models** of engineering systems.

To familiarize with methods to **characterize the dynamical** behaviour using the **models.**

To provide a good **understanding** of basic concepts of **control theory**, along with the various **control structures** & **elements**.

To describe a few **basic techniques** for **designing** control systems.

Course Contents

Modelling, Response & Stability

Introduction to Modelling: Objective, basic modelling concepts & model types, including mathematical models, their linearization and role of LTI forms.

Response Basics: I/O form, block diagram representation and manipulation, test signals, Laplace transform and transfer function concepts, basic response analyses, frequency response & its representation using bode', Nyquist plots.

Stability: Stability & response connection, asymptotic/ BIBO stability, Routh's & Nyquist stability analyses.

Control Analysis & Design

Introduction to Control: Control objectives, open/ closed loop control structures, unity negative feedback systems, basic control actions, transient & steady-state responses, tracking/transient specifications.

Typical Control Systems: P control action and concept of root locus, PD, PI, and PID control actions.

Design Procedures: Specifications in Time / frequency domains, design rules & methodologies for P, PI, PD and PID control systems.

Course Pre – requisites

The course has **no formal prerequisites**. However, familiarity with the **following** would be **useful.**

Ordinary Differential Equations and their solution.

MATLAB & SIMULINK, as well as other numerical solution techniques.

Elementary **complex analysis.**

Evaluation & Attendance Policies

1 Assignment	- 15%
2 Quizzes	- 20%
Mid-semester	- 20%
Regular Class Tests	- 20%
End-semester	- 25%

No DX grade

Audit based on minimum **passing** marks.

Evaluation Compensation Policy

No compensation will be admissible for **missed** class tests, **for any reason,** including medical.

Quizzes & **mid-semester,** if missed for **medical reasons,** will be **compensated** through a single **test**, conducted towards the **end of the course.**

Medical re-examination for **end-semester** will be as per the **institute rule.**

Quiz / Compensatory Test Schedule

Quiz No. 1 – Monday **26th August**	- Class Hour
Quiz No. 2 – Monday **14th October**	- Class Hour
Compensatory Test – During **last week** of instructions	

Texts / References

1. **Nise**, ‘Control Systems Engineering’, 3rd Ed., John Wiley & Sons, 2001

2. **Gopal**, ‘Control Systems – Principles and Design’, 3rd Ed., Tata McGraw-Hill, 2008.

3. **Ogata**, ‘Modern Control Engineering’, 5th Ed., PHI, EEE, 2010.

4. **Dorf and Bishop,** ‘Modern Control Systems’, 12th Ed., Prentice Hall, 2011.

Modelling the Dynamics

Role of Modelling in Control

In order to proceed with **control design**, we need to estimate the **deficiencies** that exist in the plant/ **process**.

This can be done by **examining the behaviour** of the plant under **operating conditions**, which, in turn, requires a **methodology** for generating relevant **responses.**

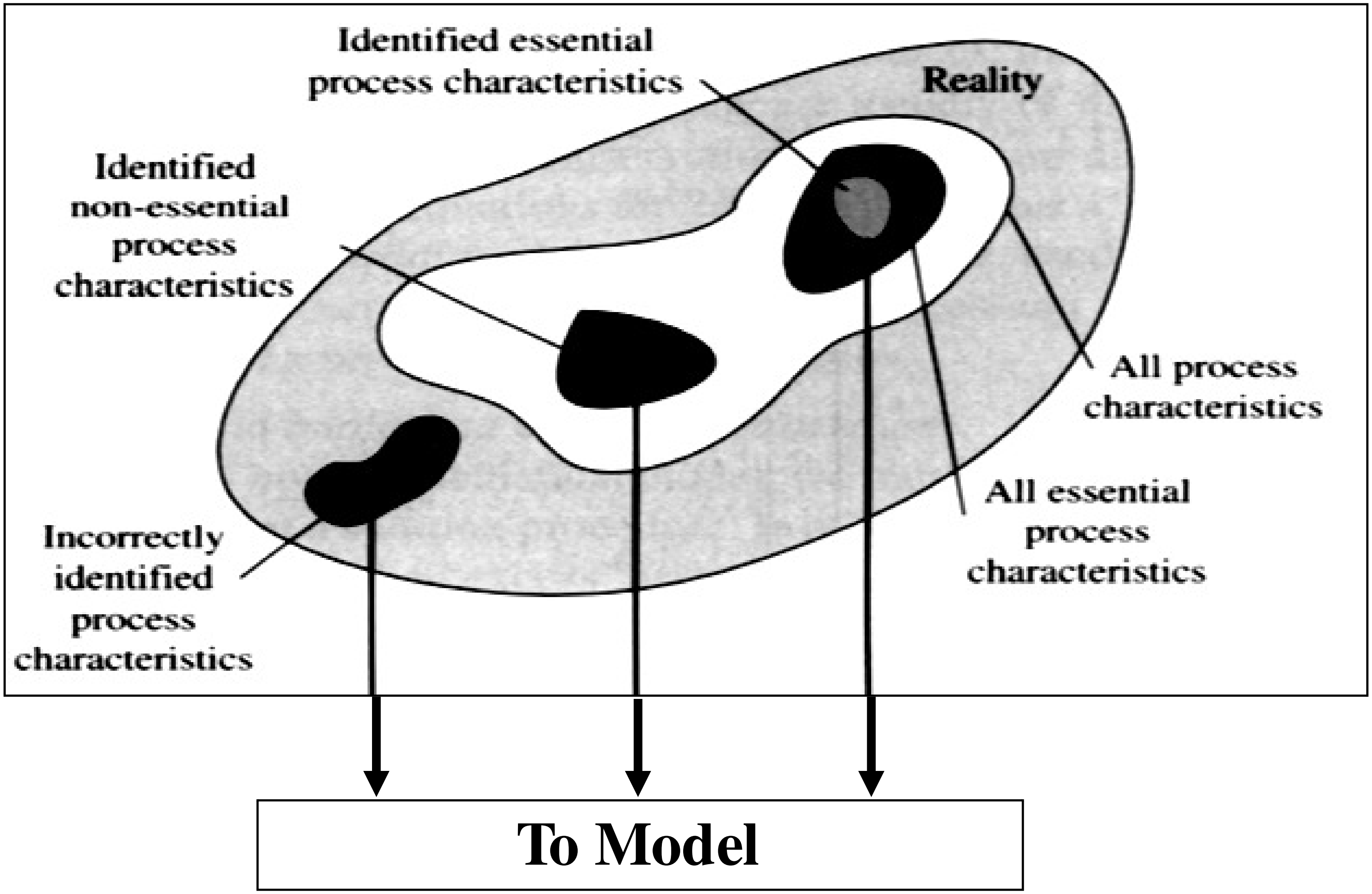
Modelling is the first step that **helps** a control designer to generate **responses**, as applicable in the **design context.**

What is a Model?

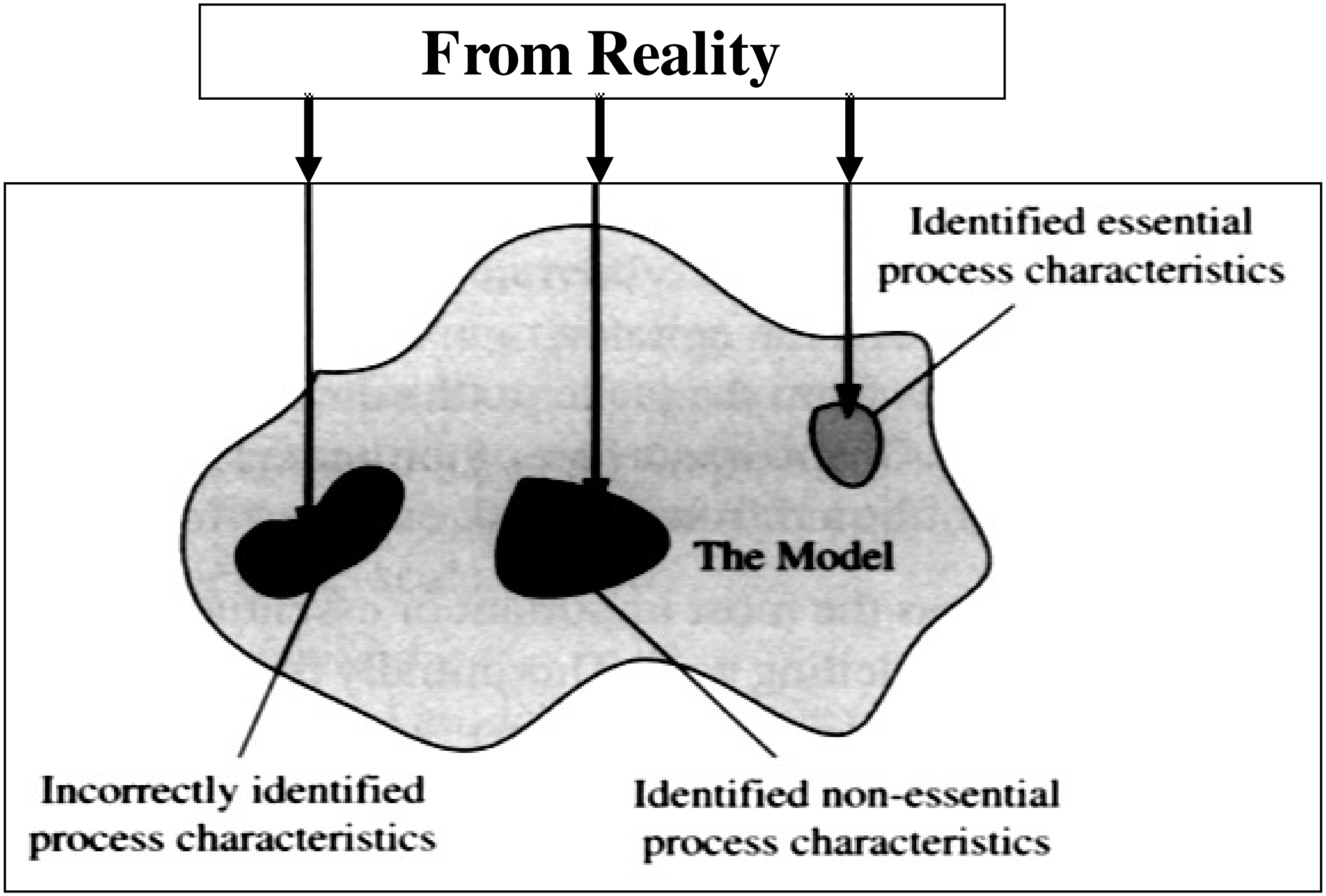
Model is a view of the system that captures the **objectives** to be satisfied by that **system.**

Model represents an imitation of the reality, in terms of those **features** that describe the **operation** of any system.

Analysis of Reality



Reality – Model Mapping



Summary

Control discipline is an important **enabling technology** that ensures **desired** dynamical **performance** from systems, which are **deficient** in these aspects.

Modelling is the important first step for **understanding existing** characteristics & synthesizing **compensation**.