

**Indian Institute of Technology Delhi**  
**Electrical Engineering Department**

01-09-2011.

**Sub : NIQ for Inverted Pendulum with Balance Rod**

On behalf of duly constituted purchase committee, sealed quotations are invited from the dealers for **Inverted Pendulum with Balance Rod**, useful for conducting system Identification / modern control experiments as per specifications given below.

**1. INVERTED PENDULUM WITH BALANCE ROD.**

(Complete Turn-Key System)

The system should be based on horizontal balancing rod in the presence of gravity to control the vertical Pendulum rod. By adjusting mass properties, roots of the plant should be variable to make the control problem range from being relatively simple to theoretically impossible.

**The system should have following features:**

**Dynamics:** 4th order, non minimum phase, open loop unstable, kinematic & gravitationally coupled nonlinearities.

**Parameter adjustment:** Adjustable vertical and horizontal rod mass, inertia and CG offset.

**I/O:** SISO, SIMO.

**Poles :** Adjustable in the range of 0.4 - 1.2 Hz

**Feedback:** High resolution encoders ( min 16,000 count/rev, $\theta$  and 44,000 count/m, x)

**Bench-top size:** maximum 30x30x40 cm. (12x12x16 in.)

**User interface software package** with library of control forms, trajectories, graphics, and data management.

Interface electronics box with integrated power supply, servo amplifier, with all necessary cabling.

**Student and Instructors manuals** with theory, experiments, solutions, and operating instructions. Mat Lab scripts for modeling of multiple plant configurations, control analyses, design, and simulation. And real time simulink interface.

**Safety Features:** Travel limit micro switches ( horizontal rod), fail safe shutdown, limit cushions(vertical rod) and amplifier over-current protection. In firmware ( complete system only) : i<sup>2</sup>t thermal protection.

**DSP based real-time controller** with embedded control firmware should also be provided. User interface software package should also be provided. Interface electronics box with integrated power supply, servo amplifier, and DSP board interface with all necessary cabling must be there with the apparatus.

Real-time Simulink interface via Matlab Real-Time Window Target : MatLab interface to analyze Apparatus designed and simulate & implement real time control from same host using MatLab/ Simulink should be provided.

Inverted Pendulum Experiments: Students should be able to conduct at least following experiments

1. Plant Identification. Identification of the plant parameters and control gains using classical techniques and uses these to construct numerical plant models for control design.
2. Successive Loop Closure Design.
3. Dynamic Filter Controller Augmentation.
4. LQR Control Design.
5. Tracking Control etc.

*Madhav*

**Terms and Conditions:-**

1. Please submit the TECHNICAL and FINANCIAL bids in separate sealed envelopes. Mark the two envelopes clearly as “**Technical Bid**” and “**Financial Bid**”. Both the sealed envelopes should be sent in a single sealed envelope, with clearly marked as Quotation for “**Inverted Pendulum with Balance Rod**”. The quote should reach the following address on or before **15/09/2011 up to 5.00PM**.

**Name : Dr. Mashuq-un-Nabi**  
**Address : Control Lab,**  
**Room No. II-214,**  
**Department of Electrical Engineering,**  
**IIT Delhi, New-Delhi – 110016 ( India )**

2. Please quote the price at FOB / CIF New- Delhi, inclusive of installation charges.
3. Quote should be in Indian Rupces as well as US Dollars and to be valid for at least three months.
4. Attached all technical literature and list of similar installation done in India.
5. A minimum of three years comprehensive onsite warranty, also exclude warranty for three years.
6. Mention if you can provide any technical support like training of IIT Delhi personal at IIT Delhi or in your factory and providing a technical person for operation of the machine for the initial period of 2 years. Kindly mention about this in technical bid.
7. If the quote is being submitted by the representative of the principals/manufactures themselves, a valid Agency ship/ Dealership certificate authorizing the agent to quote to IIT Delhi on behalf of the Principals should be enclosed.
8. The institute reserves the rights to accept/reject any/all quotations without assigning any reasons thereof.
9. Complete set of manuals for the operation of the equipment should be given. All circuit diagram, other mechanical and electrical schematics must be provided to main unit, sub systems and accessories.
10. Delivery as early as possible in weeks on receipt of PO.
11. Clearly specify the installation requirements – Such as space, power, frequency, environment( Temperature and Humidity)
12. If the item quoted are proprietary in nature, please enclose proprietary certificate from the principals stating “certificate that ----- is proprietary item of M/s ----- and no other manufacture make these items”.
13. If the bidder is Indian agent, the agency certificate should be enclosed.
14. Please produce compliance certificate for the specification.
15. Please ensure that the Indian agent has been enlisted with the Department of Expenditure, evidence may please be attached.
16. All bank charges payable in India are to buyer’s account and the bank charges in seller’s country to seller’s account.

*Mashuq-un-Nabi*  
**Dr. Mashuq-un-Nabi**  
**(Buyer)**