University although the equipment is obsolete and can provide its students with basic education necessary for mining engineers.

Table 3-13 shows a model for themes of experiments and necessary equipment for a mining engineering department. For Dharma Agung University it would be appropriate to provide equipment necessary for observation of minerals since it has nearly nothing. For University of Sriwijaya, oil analysis related equipment will be provided as discussed above.

3.2.5 Relation to the HEDS

This grant aid cooperation project was requested by the Indonesian government in the process of the HEDS project. The HEDS project is already in progress in the form of a project type technical cooperation scheme and R/D was signed between the Japanese side and the Indonesian side on April 12, 1990. As shown in Table 2-4 and Fig. 3-1, the above mentioned technical cooperation scheme is closely linked with this grant aid cooperation project and directs this. The relations of both projects are as follows:

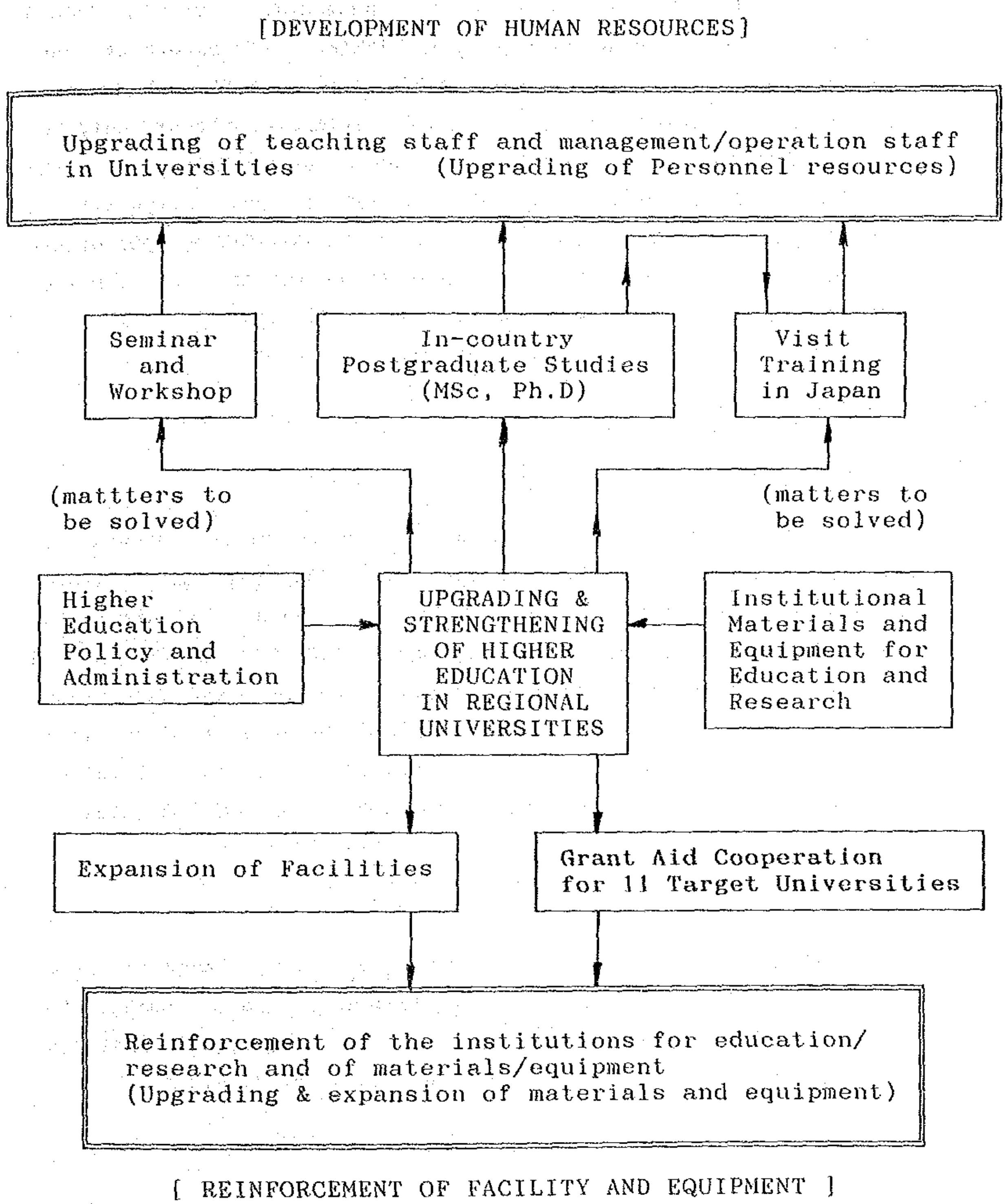
(1) The technical cooperation project trains young teaching staff of the engineering departments of the 11 target universities in three allotment in five years. Those who obtained higher degrees through this training and teaching staff who attended seminars and workshops on recent topics in science and technology and on recent engineering education methods are expected to utilize equipment provided by the grant aid project for experiments and practices of S-1 grade students of the engineering departments of the 11 target universities. The above mentioned workshops and seminars are also activities of the technical cooperation project.

(2) The technical cooperation project provides the host training institution which performs training mentioned above with equipment which is to be used by the trainees for their research. In the circumstances, these young teaching staff are expected to acquire skills of experimental technique and equipment maintenance. Thus the maintenance system of equipment for S-1 grade student experi-

ments provided through the grant aid project will be improved and effective and ingenious use of the equipment is expected on their own initiatives.

(3) Provision of eduational and training equipment by this grant aid will activate student experiments and increase opportunities of the participation of more teachers in ORT (On the Research Training) concerning university management such as budget control, facility maintenance, administration of practice courses.

Figure 3-1 CONCEPT DIAGRAM OF THE PROJECT



3.2.6 Basic Policy for Implementation of Grant Aid Cooperation

The present evaluation confirms the benefits, feasibility and the project implementation capacity of Indonesia. It is judged appropriate to implement this project within the framework of grant aid of the Japanese government since the purpose and expected results are in line with the grant aid rationale. Accordingly, on the assumption of a grant aid of the Japanese government, the outline of the Project will be reviewed and a Basic Design will be prepared as in the following. However, it is considered appropriate to modify part of the request, as mentioned in the evaluation of requested facilities and equipment.

3.3 Outline of the Project

3.3.1 Executing Body and Operation System

The executing Body of this project is the Directorate General of Higher Education (DGHE), Ministry of Education and Culture, Indonesia. As shown in Diagram A-13-2 in Appendix 13, within the DGHE, Bureau of Academic Affairs, Bureau of Student Affairs and Bureau of Research and Community Services are in charge directly of the national universities, while Bureau of Private Institutions is in charge of private universities on a central government level and in the regions Private Education Secretariat on a regional level.

3.3.2 Plan of Activities

The Project is to expand educational equipment necessary for practice courses for S-1 grade level (equivalent to undergraduate) students of the engineering departments of the following eleven target universities:

Target Universities:

In Sumatera

University of Syiah Kuala (Banda Aceh, national)
University of North Sumatera (Medan, national)
University of Nommensen (Medan, private)
Dharma Agung University (Medan, private)
University of Medan Area (Medan, private)
Islamic University of North Sumatera (Medan, private)
University of Andalas (Padang, national)
University of Sriwijaya (Palembang, national)
University of Lampung (Lampung, national)

In Kalimantan

University of Tanjungpura (Pontianak, national)
University of Lambung Mangkurat (Banjarmasin, national)

Target Departments:

Civil Engineering (partly including Architectural Engineering)
Mechanical Engineering
Electrical Engineering (includes Electronic Engineering)
Chemical Engineering
Industrial Management (equivalent to Industrial Engineering)
Mining Engineering
University Administration

3.3.3 Proposed Project Sites

Proposed project sites are in Seven cities in Sumatera and Kalimantan. The Location of each University is shown in Appendix 5.

3.3.4 Outline of Equipment Requested

Equipment was selected for S-1 grade student experiments in following departments as a result of detailed study of the existing equipment and expansion plans of each department.

a. Laboratory equipment for civil engineering department
b. Laboratory equipment for mechanical engineering department
c. Laboratory equipment for electrical engineering department
d. Laboratory equipment for chemical engineering department
e. Laboratory equipment for industrial engineering department
f. Laboratory equipment for mining engineering department
g. Equipment for university management

Followings are list of major practice themes and equipment.

(1) Laboratory Equipment for Civil Engineering Department

There are 11 target universities which have a civil engineering department. The following equipment will be selected for them.

- Surveying Practice Equipment (Transit, Tripod, Theodolite, Plate, Level etc.)

- Soil Test Equipment (Trimmer, Pycnometer, Liquid Limit Appratus, Practice Size Measuring Apparatus, etc.)

- Concrete Testing Equipment (Balance, Mixer, Compressive Strength Test, Dryer, etc.)

- Pavement Testing Equipment (Penetration Test Equipment, Softening Point Tester Set, Flash Point Tester, etc.)

- Hydraulics Experiment Equipment (Ventury Meter, Wave Generation Tank, Open Channel Apparatus, Orifice Experiment Unit, etc.)

(2) Laboratory Equipment for Mechanical Engineering Department

There are 8 target universities which have a mechanical engineering department. The following equipment will be selected for them.

- Workshop Practice Equipment (Lathe, Milling Machine, Drilling Machine, etc.)

- Material Testing Experimental Equipment (Universal Testing Machine, Universal Tensile Machine, Brinnell Hardness Tester, Chalpy Impact Testing Machine, etc.)

- Heat Treatment and Casting Practice Equipment (Electric Furnace, Sand Mill, Shell Mould etc.)

- Welding Practice Equipment (Spot Welding Machine, Arc Welding Machine, etc.)

- Fluid Machinery Experimental Equipment (Piping System, Pressure-loss Measuring Unit, Turbine Pump, Oriffice, etc.)

- Internal Combustion Engine Experimental Equipment (Gasoline, Engine, Specific Gravity Meter, Bomb calory meter, etc.)

- Refrigeration and Heat Transfer Experimental Equipment (Refrigerator, Calory Meter, etc.)

- Instrument/Machine Mechanics Experimental Equipment (Vibration Meter, Torquemeter, Oscilloscope, etc.)

- Common Miscellaneous Tool (Spaner, Piperench, Hammer, etc.)

(3) Laboratory Equipment for Electrical Engineering

There are 7 target universities which have an electrical engineering department. The following equipment will be selected for them.

- Electromagnetic Basic Experimental Equipment (AC/DC Voltmeter, Ammeter, Variable Transformer, etc.)

- Electrical Machine Experimental Equipment (Wattmeter, Experimental Induction Motor, Torque Meter, etc.)

- High Voltage Experimental Equipment (Silicon Rectifier, High Voltage Test Set, Impulse Voltage Generators, etc.)

- Tele-communication and Electronics Equipment (Pulse Generator, X-Y Recorder, Microprocessor and Computer Testing Unit, etc.)

- Common Electrical Tool (Drill, Tester, Spanner, Pliers, etc.)

(4) Laboratory Equipment for Chemical Engineering Department

There are 3 target universities which have a chemical engineering department, following equipment will be selected for them.

- Chemical Analysis Experimental Equipment (PH Meter, Platinum Crucible, Electrical Furnace, Refractometer, etc.)

- Physical Properties Measurement Equipment (Pycnometer, Ostwald-Viscosity Meter, Drying Oven, etc.)

- Fluid Experimental Equipment (Orifice Flow Meter, Centrifugal Pump, Packed Column, etc.)

- Heat Conductance Experiment Equipment (Stirrer, High and Low Temperature Tank, Millivolt Meter, etc.)

- Distillation Experiment Equipment (Microflask, Mantle Heater, Packed Column, etc.)

- Drying Experiment Equipment (Drying Chamber with Balance, Blower, etc.)

- Adsorption Experiment Equipment (Beaker, Stirrer, Fluorescence Adsorption Spectrophotometer, etc.)

- Filtration Testing Equipment (Leaf Filter, Vacuum Pump, etc.)

(5) Laboratory Equipment for Industrial Engineering Department

There are 4 target Universities which have an industrial engineering department. The following equipment will be selected for them.

- Operational and Production Management and Statistics Practice Equipment (Video, Screen, Slide Projector, etc.)

- Production Design Practice Equipment (Drafter, Light, Table, etc.)

- Factory Planning Practice Equipment (Layout model, Machine Model, Template, etc.)

- Work Engineering Practice Equipment (Microchronometer, Stopwatch, etc.)

- Production/Human Engineering Practice Equipment (Video, Tape Recorder, Stopwatch, etc.)

(6) Laboratory Equipment for Mining Engineering Department

There are 2 target Universities which have a mining engineering department. The followings equipment will be selected for them.

- Rocks, Mineral Observation/Analysis Equipment (Rock Cutter, Small Sized Grinding Machine set, Microscope etc.)

- Petroleum Analysis Equipment (Viscosimeter, Aniline Point Tester, Asphalt Penetration Tester, etc.)

- Prospecting Equipment (Resistivity Surveying Equipment, etc.)

3.3.5 Plan of Implementation and Operation

(1) Maintenance System

Maintenance of equipment after the implementation of the Project is in charge of the staff members of the existing departments since the target departments are existing ones which have the current curricula and practice courses. In addition to teaching staff, there are a head and 4 or 5 assistants for experiments in each laboratory. So the equipment will be maintained following the present system without increasing the number of the staff.

The ratio of the teaching staff to students in the target universities is between 1-10 and 1-20. Since the criteria for equipment selection is for basic experiments for S-1 grade students, there will be no need to increase the number of staff for conducting additional experiments made possible by the new equipment. As the higher education development program mentioned before and other expansion plans of teachers are expected to increase the number of teaching staff by more than 60% in the Repelita V, there will be no problem with the shortage of teachers.

(2) Maintenance Costs

The maintenance costs to be borne by the universities including purchase costs for spare parts and costs for electricity, water etc. will increase after the implementation of this project. However, as often mentioned, equipment provided by this project is for S-1 grade student experiments and not expensive instruments with complicated electronic circuits or precision instruments, therefore the maintenance cost increase will be negligible. It is also noted that student experiments do not use equipment which consume a large amount of electricity, water, heat etc. Although actual figures will be examined in Chapter 4, Basic Design, the following is assumed an increase for one student per year.

Laboratory equipment for civil engineering	:	Rp.1,000 - 3,000
Laboratory equipment for mechanical engineering	:	Rp.2,000 - 5,000
Laboratory equipment for electrical engineering	:	Rp.1,500 - 3,500
Laboratory equipment for chemical engineering	:	Rp.1,000 - 2,000
Laboratory equipment for industrial engineering	:	Rp.200 - 500
Laboratory equipment for mining engineering	:	Rp.500 - 1,000

The reason why any given department shows a range of figures is that the amount of equipment held at present and to be provided by other bilateral and multilateral assistance programs differs from university to university. Since the tuition fees which a student of national university pays a year is about 100,000 Rupiah, the increase is at most by 5% of the present costs. If we consider the expenses some students must pay for ITB for their training in the practice courses which they can not take in their own university due to lack of proper equipment amount to 1 to 1.5 million Rupiah, the financial benefits as a whole will surpass the small increase of a student financial burden.

The above is an outline of the Project based on the request of the DGHE and further clarified during the on site survey. The following sections will deal with a basic design of the Project.

Table 3-3 (1) Details of Model Civil Engineering Laboratory Activities

Category	Category	Purpose of Training and Description	Major Equipment Used
Surveying	Distance measurement	To measure a distance on a flat land by using a steel tape, with the required accuracy of around 1/1000.	Steel tape, linen tape, poles, marking board (or marking stake), hammer, spring balance, grip handle, and thermometer
	Precision Distance Measurement	To measure a distance at a high degree of accuracy, such as a base line for triangulation.	Steel tape for base line measurement, transit, poles, staff, linen tape, piles (intermediate and bearing piles), tin-plate sheets, spacing balance grip handle, level, thermometer, nails (lage and small), maul, and hammer
	Angular Measurement	To get acquainted with the proper setting up of the transit (or theodolite) and the method of measurement	Transit (or theodolite), tripod, marking stakes, maul, nails, hammer, field book, and pencil or pen
	Traverse Survey	To get acquainted with the outline of traverse survey by determining a point from measured distances and horizontal angles.	Transit (or theodolite), steel tape, poles, marking pins, thermometer, piles, maul, felt pen, nails, hammer, field book, and pencil or pen
	Offset Survey	To get acquainted with the method of measuring a perpendcicular distance from a reverence line to an object, which is needed to describe a location and size of the object on a topographic map.	Line tape, poles, chalk, field book, and pencil or pen
	Plane Table Survey	To get acquainted with the proper setting up of the plane table over a point and the use of related devices.	Drawing board, tripod, alidade, center marker, compass box, marking pins, poles, field book, and pencil or pen
	Leveling	To get acquainted with the proper setting up, adjustment, and use of the level, and to measure a level to a point.	Level (tilting or automatic level), staffs (2), linen tape, piles, maul, poles, field book, and pencil or pen
	Studio Survey	To determine a distance or level from a point by reading a staff set at the point through studio hairs on a telescope of a transit or alidade.	Transit, staff, line tape, field book, and pencil or pen
	Triangulation	To get acquainted with overall triangulation work by applying basic surveying techniques including distance measurement and angular measurement.	Those used in distance measurement and angular measurement
	Photo Survey	To get acquainted with the method of obtaining a stereoscopic view form aerial photographs by using the mirror stereoscope and replotting	Mirror stereoscope, aerial photographs, scale and ruler, marking pins, parallax wege

Table 3-3 (2) Details of Model Civil Engineering Laboratory Activities

Category	Category	Purpose of Training and Description	Major Equipment Used
Soil Tests	Water content Test	To determine water content which forms a basis of soil property. To monitor water content in a quantitative manner is important for engineering evaluation on soil.	Desiccator (to place a desiccant such as calcium chloride and silica gel), container picker, container (weighing tray, laboratory dish or watch glass, the similar with cover), balance (when a sample size is small, weighing capacity of 100g and reciprocal sensitiveity of 0.1g; or weighing capacity of 100 - 1,000g and reciprocal sensitivity of 0.1g), and constant temperature drying furnace (capable to maintain inside temperature at 100° C)
	Specific Weigth	To determine specific weigth (density) of soil. Specific weigth is used to calculate dead weitht of soil that is required for design calculation, including estimations of compactness of ground, earth pressue, bearing capacity, slope stability, and settlement of ground for foundation.	Trimmer, Wire saw, miter box, stright edge, plate glass, spatula, vernier calipers (accuracy : 1/200mm)
	Specific Gravity Test for Soil Particles	To determine the averge specific weight of soil particles forming a soil skeleton, which is required to determine basic properties of soil such as void ration, saturation, and compactness.	Phicnometer (3), balance (weight capacity of 200g and reciprocal sensitivity of 0.001g), thermomete (calibrated scale: 1° C), jeater, pad, evaporatin dish, disccator, constant temperature drying furnace, funnel, distilled water
	Liquid Limit Test	To determine liquid limit, as part of soil consis -tencies. Liquid limit is the minimum water content at which soil becomes liquefied and is an important indicator for classification of fine grained soil and evaluation of engineering properties of soil.	Liquid limit apparatus, drainer, spatula, kitchen aid (spatula to scrape the specimen from a brass tray), glass plate (thick), sprayer, cloth, water content measuring device
	Plastic Limit Test	To determine plastic limit as part of soil consistencies. Plastic limit is the water content which represents soil's plastic condition and a limit for the semisolid state, and used for classification of fine grained soil and estimation of soil's engineering properties.	Frosted glass plate sprayer, spatula, cloth, glass plate for mixing, container (weighing bottle with cover), 3mm diameter bar, and water content measuring device
	Mechanical Analysis	Mechanical Analysis particles by sizes. Used for classification of coarse grained soil and evaluation of soil's engineering properties.	Scale, disperser, floater for gravimeter, measuring cylinder, sieve, beaker, constant temperature water tank, 6% hydrogen peroxide solution , sodium silicate solution (specific weitht of 1.024/15° C), spatula, watch and stop watch, bottle for water pouring, thermometer,

Table 3-3 (3) Details of Model Civil Engineering Laboratory Activities

Category	Category	Purpose of Training and Description	Major Equipment Used
	Permeability Test	To determine soil's permeability which is require for design and construction of bank, drainage trench and other structure by determining the degree of water percolation into bank and ground of earth dam, river bank, reclaimed bank, or uplift to a structure to be build below ground water level.	Container for constant-head permability test (mold), upper overflow orifice, water tank (to give constant water level for the bottom), mesh, water tank for percolation into specimen, specimen container (developing tray), rammer, measuring cylinder, vernier calipers, stop watch, balance, and thermometer
	Consolidation Test	To determine coefficient of consolidation. Consolidation is defined as volume reduction of water-saturated cohesive soil due to discharge of void water when receiving load. Used to analyze the amount and rate of settlement when a load is applied to cohesive soil.	Consolidatin test set (consolidation box, loading device, weitht, support stand for consolidation box), specimen preparation set (desiccator, trimming ring pushing device, wire saw, straight edge, spatula, stop watch, rubber glove, vinyl sheet, evaporating dish, watch glass, and filter paper
	Shear Box Test	To determine shear strength parameter (cohesion c angle of internal friction ϕ) from shearing strength of soil. The result is used for calculation of earth pressure, slop stability, and bearing capacity of structure foundation.	Strain control shearing box tester (shear box (dimensions of specimen: 6cm diameter and 2cm thick)), normal force loading device, shear loading device, probe (capacity of 100 - 300kg with reciprocal sensitivity of less than 1/200), dial gauge for vertical displacement (effective length of more than 100mm, with reading scale of 1/100 - 1/200mm), filter paper (60mm diameter), and water content measuring device and specimen preparation device
	Unconfined Compression Test	To determine unconfined compressive strength and sensitivity of cohesive soil. The result is used to determine cohesion for calculation of bearing capacity of foundation ground and slope stability	Strain control unconfined compression test set (force gauge, dial gauge for gorce gauge, compression board, compression handle, dial gauge for measurement of compression), specimen preparation set (miter boxes (large and small), speciment preparation set (miter boxes (large and small and wire saw)
	Triaxial Compression Test	To determine shear strength parameter (cohesion c and angle of internal friction ϕ). As the speciment can be tested under stress and drainage near actual ground conditions, more reliable data compared to other shear tests can be obtained.	Triaxial compression test device (force gauge, dial gauge for measurement of compression, pressure chamber, specimen, piston, burette, and pressure gauge), specimen preparation device
	Compaction Test	Compation is important to obtain stability of earth structures such as road bed, subgrade, and bank. To determine soil density (maximum dry density) under water content at which the soil can be vest compacted by a specific compaction	2.5kg rammer, 2.5kg rammer, 10cm mold, 15cm mold, developing tray, sprayer, standard sieves (38.1mm 25.1cm, 19.1mm, 12.7mm, 1970), specimen extruding device, balance, straight edge, and water content measuring device

Table 3-3 (4) Details of Model Civil Engineering Laboratory Activities

Category	Category	Purpose of Training and Description	Major Equipment Used
	Indoor CBR Test	CBR is calculated by dividing test load intensity for a given penetration by standard load intensity for the penetration, and indicated in percentage. Used for determination of paving thickness or bearing capacity of ground.	Mold, color and perforated bottom slab, spacer disc, rammer, penetration piston (copper cylinder of ϕ 50mm and 200mm long), loading device (5 tons and penetration rate of 1mm/min), force gauge, perforated slab with shaft, loading slab (1.25kg, lead, more than 4 units), expansion measuring device, specimen extrucing device, cutter, straight edge, balance (weighing capacity of 20kg with reciprocal sensitivity of 10g), sieve(19.1mm 4760), water content measuring device, mixing device (developing tray and sprayer), measuring cylinders (500ml or 1,000ml), water tank, spoon, filter paper, and stop watch
	Standard Penetration Test	To determine N value, an indicator of soil hardness and compactness, by using a bore hole. As most of information related to ground conditions can be estimated from N value, the test is conducted at the time of exploratory boring.	Standard penetration sampler, knocking head, hammer, tonbi , boring rod, pipe wrench, folding wood rule, field book, chalk, bottle and box to keep specimen, scaffold
	Static Cone Penetration Test	To Penetrate a cone into ground and measure relationship between the penetrated depth and resistance, therby estimating characteristics of soil layers. Used to evaluate hardness of layers compactness of soil, stratification, an effect of ground improvement, and increase in shearing strength due to compaction	Butch double tube cone penetration tester (pressing and extracting gauge or force gauge), and fixing device (screw anchor)
	Field Vane Test	To measure shearing strength of clay at the field without taking a specimen. Applicable to very soft clay which shearing strength is affected due to disturbance by sampling or forming a specimen.	Vane and vane shaft, rod casing, measuring stand (handle, force gauge, and calibrated disk), and casing extractor
	In-place CBR Test	To determine CBR value from a field penetration test. CBR is calculated by dividing test load intensity for a given penetration by standard load intensity for the penetration, indicated in percentage. Used to determine paving thickness or bearing capacity of ground.	Load (truck, etc.), tamaza , screw jack or oil jack, force gauge, penetrating piston, dial gauge fixing divice. load slab (semi-circular lead plate, 1.25 kg, 4 or more), stand, dry sand
	Plate Bearing Test	To apply load to a rigid loading plate at the field and determine the relationship between load and displacement. From the relationship, to determine bearing capacity or coefficient fo soil reaction of foundation ground or road bed	Loading plate (steel disks of more than 22 mm thick with diameters of 30 cm , 40 cm, and 75 cm) pressure device, loading device, hydraulic jack with capacity of 5 to 40 tons), subsidence measuring device

Table 3-3 (5) Details of Model Civil Engineering Laboratory Activities

Category	Category	Purpose of Training and Description	Major Equipment Used
	In-place Permeability Test	To identify permeability of water-bearing layers at the field. This test plays an important role in developing effective measures to cope with ground water at a construction site.	Pumping well, observation well, pump, water level gauge, water measuring device, container with known volume), stop watch, thermometer, and level
	In-place Specific Weight	To determine specific weight of soil at the field The result is used in design and construction supervision to estimate compactness of earth structures such as road bed and subgrade.	Jar (4 liters), attachment, base plate, plate glass, rubber, ring, pycnometer top, valve guide, funnel, straight edge, spatula, thermometer, and water content measuring device
	Boring	(1) To drill a hole mechanically and to estimate stratification from the drilling speed, reaction, and undisturbed samples collected, thereby to observe soil or rock forming the ground. (2) To drill a hole for continuous collection of undisturbed samples, in-situ test, or measurement of ground water level.	A variety of boring rigs available, including auger boring, rotary boring, wash boring, percussion boring
	Thin Wall Sampling	To insert a thin wall tube into the bottom of a bored hole and collect soil inside the tube as a sample. Mainly used for soft clay.	Sampling tube, sampler head set, piston set, piston extension road, boring rod, wrench for overhauling of piston, handle to recover piston, bil cone, chain, turn buckle, coupling to fix piston
Tests Related to Concrete	Specific Weight Test	Specific weight of cement needs to be known for mixture secific weight of cement needs to be known for mixture design and other test. Also used to estimate an type of unknown cement or the degree of wearing.	Le Chatelier pycnometer (with allowable error per graduation of less than 0.25 cc), balance (weighing capacity of 200 g and reciprocal sensitivity of 0.1 g), constant temperature water tank (adjustable to a constant temperature range within 20 ± 2° C by placing a pycnometer), completed dehydrated hearing oil or kerosene, thermometer, evaporating disk, dry cloth and wire
	Fineness Test	Fineness of cement is an important physical factor to govern characteristics of cement and concrete, and it allows the estimation of properties of mortar and concrete prior to production	production. Blein air chuter set, balance (weighing capacity of 100 g with reciprocal sensitivity of 1 mg), manometer fluid, stop watch, watch glass, writing brush, spoon, sampling bottle
	Cement Setting Test	To measure the initial set and final set after cement has been mixed with water. The time of setting should be within a specific range to avoid any trouble	Vicat needle set, balance (weighing capacity of 1 kg with reciprocal sensitivity of 1 g), bowl and spoon for mixing mortar, measuring cylinder (200 cc, with minimum graduation of 1 cc), glass plate, knife, watch, wet cloth
	Autoclave Soundness Test	To check stability of cement which causes expansive crack or deflection to concrete and deteriorates durability of structure, by measuring expansion in setting	Autoclave, balance (weighing capacity of 1 kg with reciprocal sensitivity of 1 g), measuring cylinder, bowl and spoon for mixing, glass plate, watch (with the second hand), moisture box (capable of maintaining temperature of 20 ± 3° C

Table 3-3 (6) Details of Model Civil Engineering Laboratory Activities

Category	Category	Purpose of Training and Description	Major Equipment Used
			and humidity over 80 %)
	Strength Test	To check binding force of cement actually produced. This serves as a quality inspection on cement and indicates strength of concrete using the cement.	Mixing devices, flow test equipment, flow table, flow cone, rammer, vernier calipers, rubber plate to remove mortar), test piece preparation devices (triple form to make mortar specimen, rammer, brush to apply mineral oil, wood hammer, straight edge, bamboo spatula), curing equipment (moisture box capable of maintaining over 20 C ± C), Mihaelis double lever bending test machine, automatic weighing scale (weighing capacity of 10 kg with reciprocal sensitivity of 10 g), rule for marking support points, compressive test machine (with variable capacity of 20, 10, 5, and 2 tons), small water tank (container to soak a test piece taken out of the curing tank prior to testing
	Sieve Analysis Test for Aggregates	To determine grading, fineness modulus, and maximum size of coarse aggregate. Required to accept or reject aggregate, to determine adequate portions of different types of aggregate, as well as for mixture design and quality control on aggregate.	Balance (having accuracy of more than 0.1 % of total weight of specimen), sampler, standard seives (0.15, 0.3, 0.6, 1.2, 2.5, 10, 15, 20, 25, 30,40, 50, 60, 80, 100 mm), sieving machine, dryer
	Specific Gravity and Coefficient of Water Absorption for Fine Aggregate	1) To determine general properties and absolute volume of fine aggregate for mixture design 2) Coefficient of water absorption is determined to indicated the degree of void inside fine aggregate particles and to adjust and amount of water in mixture design, while serving as one indicator of aggregate quality	Balance (weighing capacity of 1 kg, with reciprocal sensitivity of 0.1 g), flask (500 cc at 20° C), flow cone and rammer to measure surfac drying condition (340 ± 15 g in mass, with 25 ± 3mm diameter circle in section at one end), sampler, water tank, dryer, desiccator, pipete, and funnel
	Specific Gravity and Coefficient of Water Absorption for Coarse Aggregate	1) To determine general properties and absolute volume of coarse aggregate for mixture design 2) Coefficient of water absorption is determined indicate the degree of void inside coarse aggregate particles and to adjust an amount of water in mixture design, while serving as one indicator of aggregate quality.	Balance (weighing capacity of over 5 kg, with reciprocal sensitivity of less than 0.5 g, capable of measuring nominal weight in water), mesh cage (made of less than 3 mm mesh. 20 cm in diameter and 20cm in height), water tank, dryer desiccator
	Specific Weight and Solid Volume Percentage	Required for concrete mixing, proportioning, and batching at the field.	Balance (accuracy of more than 0.2 % of total mass of specimen), specific weight measruring container, rammer, and dryer
	Sruface Water Percentage for Fine Aggregate	To determine possible influence of surface water on fine aggregate upon water to be mixed with motor or concrete, and to adjust amount of water accordingly.	Balance (weighing capacity of more than 2.0 kg, with reciprocal sensitivity of reciprocal sensitivity), Chubman flask (capacity of 2 to 3 times when lightly filled, with minimum graduation at every 0.5 cc), and pipette

Table 3-3 (7) Details of Model Civil Engineering Laboratory Activities

Category	Category	Purpose of Training and Description	Major Equipment Used
	Slump Test	To measure consistency of fresh concrete, and widely used to evaluate workability of concrete.	Slump cone, rammer (16 mm diameter and 50 cm long round steel bar, with semi-spherical end), slump measurement device, watertight flat plate, scoop, and spatula
	Air Content of Fresh Concrete	As air content of concrete significantly affects properties of concrete (including durability, strength, water tigthness, specific weight), this test is conducted to measure air content of fresh concrete.	Washington type air meter and acessories, rammer (16 mm diameter and 50 cm lond round steel bar), wood hammer, and scope
	Compressive Strength Test	(1) To determine compressive strength of concrete in a given mixture and to select a mixture suitable for obtaining the required strength (2) To check if materials (e.g., cement, aggregates, water, admixtures) is suitable for use, and to select materials which can produce concrete with required performances in the most economical manner. (3) To estimate other performances (e.g., bending strength, tensile strength, and modulus of elasticity)from compressive strength (4) Used for quality control on concrete (5) To determine quality of concrete constructed in as actural structure and to check if it has compressive strength and other performances assumed in design. Also used to determine the time of removing the form or the time of prestressing	Form for test piece production (15 cm diameter, 30 cm in height), rammer (16 mm diameter and 50 cm long round steel bar), capping glass, spatula, vernier calipers, scoop, concrete mixer and accessories, compression tester
	Tensile Strength Test	To determine tensile strength of concrete by placing a cylindrical test piece on its side and applying concentrated load to both ends of its diameter. Tensile strength is very important in concrete road slabs and water tanks which receive bending force directly.	Form for test piece production (15 cm diameter, 30 cm in height), rammer (16 mm diameter and 50 cm long round steel bar), capping glass, spatula, vernier calipers, scoop, concrete mixer and accessories, compression tester
	Bending Strength Test	To determine bending tensile stress on the tesile side by applying bending moment to a concrete beam up to destruciton	Form for test piece produciton (15 cm x 15 cm diameter, more than 53 cm in height), rammer (16 mm diameter and 50 cm long round steel bar), scale, spatula, vernier calipers, scoop, concrete mixer and accessoried, compression tester
	Mixture Design	To select mixture design which provides sufficient strength durability, water-tigthness and other performance required for a particular sturcture, and minimizes the weight of water per unit volume while maintaining sufficient workability.	Mixer (tilting type with capacity of 50 to 100 L, or forced mixer for concrete of stiff consistency), weighing scale, material containers shovel mixing plate, slump tester set, air meter set form for test piece production, curing equipment, and strength tester

Table 3-3 (8) Details of Model Civil Engineering Laboratory Activities

Category	Category	Purpose of Training and Description	Major Equipment Used
Tests Related to Pavement	Penetration Test for Asphalt	To measure cosistency of solid or semisolid asphalt, which is indicated as the degree of penetraiton by probe.	Penetration test equipment (penetration meter, standard probe, container, glass plate), constant temperature water tank, thermometer, stop watch
	Softening Point Test for Asphalt	To determine temperature at which asphalt begins to high temperature. More precisely, the softening point is the temperature at which asphalt softens and drips to a specific distance when being heated under spedific conditons.	Softening point tester set (ring, ball, ball guide, ring base, heating vane, thermometer, heater, metal plate), stop watch, constant temperature water tank, brass plate for shaping, knife for shaping, and tweezers
	Ductility Test	To determine ductility of asphalt, which is measured by pulling a specimen at a specific speed as the length of extension (cm) at which the specimen is broken	Ductility test set (ductility tester, form, metal plate, thermometer), constant temperature water tank, and knife
	Flash Point Test	As asphalt is heated to attain suitable fluidity, the flash point needs to be determined to avoid a fire hazard.	Flash point tester (sample cap, heating plate, support for heating plate, heater, thermometer, thermometer holder, test flame nozzle), wind shield, and stop watch
	Engler Degree Test	To determine if asphalt emulasion has required cohesion when being sprayed or mixed. Engler degree is indicated by ratio of time required for a specimen in specific amount (50 cc) at a specific temperature to flow out of discharge port to time required for distilled water to flow out under the same conditions	Engler degree tester set (engler meter, thermometer wood plug, heater, receiver), constant temperature water tank, stop watch, and strainer (840mm sieve)
	Marshall Stability Test	To determine the degree of resistance of asphalt mixture for pavement against displacement due to load. To produce a cylindrical test piece by compacting hot-laid mixture asphalt compound containing the maximum aggregate size of 25 mm or less, and to determine its density and percentage of void, then load and displacement upon destruciton	Test piece extractor, Marshall tester (load tester, loading head, strain ring, flow meter), form (cylinder with inner diameter of 101.6 mm and height of 76.2 mm, bottom plate, collored), compaction hammer, compaction stand, mold holder, heater set (dryer, heating plate, gas stove, gas burner), constant temperature water tank, asphalt mixer, standard sieves (0.074, 0.15, 0.3, 0.6, 2.5, 5, 13, 20, 25 mm), thermometer (200 ℃), shovel, gloves (rubber, cotton), container for heating aggregates, container for heating asphalt balance weighing capacity of more than 5 kg, with reciprocal sensitivity of 1.0 g or less)
	Extraction Test for Asphalt Mixture	To measure asphalt content by the extraction test to see if it complies with design. Important test in terms of quality control and inspection on asphalt mixture.	Extraction tester set (bowl, centrifuge), drying furnace, balance (weighing capacity of 5 kg, with reciprocal sensitivity of 0.5 g or less), filter ring or paper, weighing scale for analysis, heating tray (125 cc), measuring cylinder (2,000 cc), steaming tank, gas burner, desiccator development tray, beaker, spatula, scoop, and brush

Table 3-3 (9) Details of Model Civil Engineering Laboratory Activities

Category	Category	Purpose of Training and Description	Major Equipment Used
	Mixture Design	To design asphalt mixture with high stability, flexibility, abrasion resistance, durability, and workability, by using Marshall stability testing method. Asphalt mixture is produced by hot-laid plant mixture of coarse and fine aggregates, filler, and asphalt.	Same as marshall tester set
	Abrasion Test	To determine if coarse aggregate can be used for concrete requiring abrasion resistance	Balance (weighing capacity of more than 5 kg, with reciprocal sensitivity of 1 g), standard sieve set (1.7, 2.5, 5, 10, 15, 20, 25, 40, 60, 80 mm), steel balls (6 to 12 balls having 1.74 cm diameter and 390-445 g in weight each), Los Angeles tester
	Tensile Strength Test fo Concrete	To determine tesile strength of concrete by placing a cylindrical test piece on its side and applying concentrated and to both ends of its diameter. Tensile strength is very important in concrete road slabs and water tanks which receive bending force directly.	Form for test piece production (15 cm diameter 30 cm in height), rammer (16 mm dameter and 50 cm long round steel bar), capping glass, spatula, vernier calipers, scope, concrete mixer and accessories, compression tester
	Bending strength Test for Concrete	To determine bending tesile stress on the tensile side by applying bending moment to a concrete beam up to destruction	Form for test piece produciton (15 cm x 15 cm diameter, more than 53 cm in height), rammer (16 mm diameter and 50 cm long round steel bar), scale, spatula, vernier calipers, scoop, concrete mixer and accessories, compression tester
	Indoor CBR Test	CBR is calculated by dividing test load intensity for the penetraition, and indicated in percentage used for determination of paving thickness or bearing capacity of ground	Mold , collar and perforated bottom slab, spacer disc, rammer, peneration piston (copper cylinder ¢ 50mm and 20 mm long), loading device (5 tons and penetraiton rate of 1 mm/min), force gauge, perforated slab with shaft, loading slab (1.25 kg, lead, more than 4 units), expansion measuring device, specimen extruding device, cutter, straight edge, balance weighing capacity of 20 kg, with reciprocal sensitivity of 10 g, sieve (19.1 mm, 4760), water content measuring device mixing device (developing tray and sprayer), measuring cylinders (500 ml or 1,000ml) water tank, spoon, filter paper, and stop watch
	In-place CBR Test	To determine CBR value from a field penetration test. CBR is calculated by dividing test load intensity for a given penetration by standard load intensity for the penetraion , indicated in percentage. Used to determine paving thickness or bearing capacity of ground	Load (truck, etc.), tamaza , screw jack or oil jack, force gauge, penetrating piston, dial gauge dial gauge fixing device, load slab (semi-circular lead plate, 1.25 kg, 4 or more), stand, dry sand
	Plate Bearing Test	To apply load to a rigid loading plate at the field and determine the relationship between	Loading plate (steel disks of more than 22 mm thick, with diameters of 30 cm, 40cm, and 75 cm),

Table 3-3 (10) Details of Model Civil Engineering Laboratory Activities

Category	Category	Purpose of Training and Description	Major Equipment Used
		load and displacement. From the relationship, to determine bearing capacity or coefficient of soil reaction of foundation ground or roadbed/ subgrtade	pressure device, loading device (hydraulic jack with capacity of 5 to 40 tons), subsidence measuring device
Tests Related to Hydraulics	Stability of Floating Body	To measure draft of a floating body and to understand the relationship between the Archimedean principle and buoyancy. To underastand limiting conditions for stability of the floating body by varying the center of gravity as well as the center of buoyancy.	Floating body (around 30 x 20 x 40cm, with bolt hole), movable weight (300 g iron piece which is threaded at the center of circular shape), fixed weight (rectangular shaped, smaller than the bottom area of the floating body), 100 g, 200 g, and 800 g each, ruler, balance (sensitivity of around 1 g), bolt (65-70 cm lond and ¢9 mm), water tank (60 x 50x 80 cm), plumb, thermometer
	Certification of Notch	Weir is a structure set in a waterway to measure water flow and is classified according to shape of opening, triangle, trapezoid, and circle. The triangular weir(notch) used here is designed to ensure accurate measurement for relatively a small rate flow	Stop watch, steel tape, flow valve, flow valve, point gauge, measuring cylinder, open channel
	Experiment on Venturimeter	To get acquainted with the use of venturimeter, and to understand the theorem of Bernoulli through the experiment.	Venturimeter, flow measuring devices (triangular weir, box, scale, etc.), differntial manometer, stop watch, thermometer
	Laminar Flow and Turbulent Flow	To understand laminar flow and turbulent flow which are distinguished by the Reynolds number, and to measure the critical Reynolds number.	Reynolds number measuring instrument and accessories, calouring liquid, beaker (21), measuring cylinder (21), stop watch, and thermometer
	Oridinary Flow, Jet Flow Hydraulic Pump	Water flow in an open channel takes either of three patterns ordinary flow, jet flow, and critical flow. To observe each flow and transit from ordinary flow to jet flow, and vice versa.	2 point gauge, stee. tape, stop watch, open channel, flow measruing instrument (notch or similar one certified), dam to gemerate critical flwo, downstream sheeting board, thermometer
	Discharge from Gate	To understnad that the rate of discharge from a gate can be theoretically determined by applying the Bernoulli formula, and to measure the coefficient of discharge which serves as a correction factor for theoretical values.	Sluice gate, poing gage, flow measruign device
	Friction Loss in Pipe	Even if water flows normally through a pipe with a uniform diameter, energy loss occurs due to friction with a pipe wall. To measure piezo head at various points in the pipe, thereby to verify pressure drop, and to determine the coefficient of friction loss on the pipe wall	Pipe for experiment, stop watch, measuring cylinder, steel tape, and thermometer
	Experiment on Sedimentaion	To measure the sedimentation rate of suspended particles in a section with the uniform sedimentation rate, and to understand the relationship between the drag coefficient and	

Table 3-3 (11) Details of Model Civil Engineering Laboratory Activities

Category	Category	Purpose of Training and Description	Major Equipment Used
		Reynolds number. Measuring cylinder, steel ball, grycerin, vernier calipers, micrometer, stop watch, and steel tape	
	Experiment on Orifice	To understand that the discharge rate at the orifice can be determined theoretically by applying the Bernoulli formula, and to measure the coefficient of discharge which is a correction factor for theoretical values.	Orijice for experiment, measuring cylinder, stop watch, vernier calipers, and flow metering value
	Distribution of Current Speed in Pipe	To measure current speeds at various points in a pipe and to understand that distribution of current speed is expressed by logarithmic or exponential rule. Also to check that current spped and flow rate measures agree with theoretical values.	Pipe, dynamic pressure pipe (a copper pipe having inner diameter of 1.5 to 2 mm, covered by another copper pipe with external diameter of 5 to 6 mm), differential manometer, tilt stand, vernier calipers, steel tape, thermometer, flow rate measuring device.
	Energy Loss due to Rapid Change in Pipe Diameter	For water flowing in a pipe, energy loss occurs due to change in sectional area of the pipe. To measure the piezo head before and after a pipe which section rapidly increases or decreases, therby to verify energy loss in water flow due to rapid change in sectional area.	Stop watch, measurring cylinder, steel tape.
	Measurement of Current Speed Distribution in Open Channel	To measure cureent speeds in an open channel, to understand how they are distributed, and to draw uniform and vertical current speed distribution curves. To calculate the average current speed at each cross section from measured current speeds, and to determine the flow rate. Then to compare the results to theoretical values.	Open channel with variable slope, flow rate measuring device, Pitot tube, differntial manometer, point gauge, steel tape, thermometer, ruler
	Experiment on Uniform Flow and Nonuniform Flow in Open Channel	Normal flow is divided into uniform flow where water depth and current speed does not change from place to another and nonuniform flow where water depth and current speed change. As for uniform flow, water depth and roughness coefficicent are determined. As an example of nonuniform flow, a weir is set at the downstream end to observe changes in flow between differnt locations. Then to measure water surface pattern and compare the result to theoretical backwater curves.	Open channel with variable slope, flow rate measuring device (notch, venturimeter, and similar one certified), 3 point gauge, steel type and tape line.
	Experiment on Wave Motion	To study the relationships between wave period, water depth, and wavelength through basic experiments on wave motion, and to understand wave motions in lakes and seas.	Wave generation tank, stop watch, steel tape, tape line
	Measurement of Flow Rate in River	To measure current speeds at a cross section of a river and determine the current speed	Current meter, tape line, transit, stop watch

Table 3-3 (12) Details of Model Civil Engineering Laboratory Activities

Category	Category	Purpose of Training and Description	Major Equipment Used
		distribution and average flow rate for the section. This is very important for river improvement and maintenance, and flow control measures.	

Table 3-4 (1) Actual Activities in Civil Engineeirng Laboratories

Laboratory Practice / University	UNSYIAH	USU	NOMMENSEN	UMA	UDA	UISU	UNAND	UNSRI	UNILA	UNTAN	UNLAM
I. Surveying Practice											
1) Disatnace Surveying	*	*	*	*	*	*	*	*	*	*	*
2) Precise Distance Surveying		*									
3) Angular Measurement	*	*	*	*	*	*	*	*	*	*	*
4) Traverse Surveying	*	*	*	*	*	*	*	*	*	*	*
5) Offset Measurement	*	*	*	*	*	*	*	*	*	*	*
6) Plane Table Surveying			*								
7) Levelling	*	*	*	*	*	*	*	*	*	*	*
8) Studio Surveying		*									
9) Triangular Surveying		*									
10) Photogrammetry		*									
II. Experimental Methods in Soil Mechanics											
1) Moisture Content Test	*	*	*	*	*	*	*	*	*	*	*
2) Unit Weight Test of Soil	*	*	*	*	*	*	*	*	*	*	*
3) Specific Gravity Test of Soil Particle	*	*	*	*	*	*	*	*	*	*	*
4) Liquid Limit Test	*	*	*		*	*	*	*	*	*	*
5) Plastic Limit test	*	*	*		*	*	*	*	*	*	*
6) Grain Size analysis	*	*	*	*	*	*	*	*	*	*	*
7) Permiability Test	*	*	*		*		*	*		*	*
8) Consolidation Test	*	*	*	*	*		*	*	*	*	
9) Direct Shear test	*	*	*	*	*		*	*		*	
10) Unconfined Compression test	*	*	*	*	*		*	*		*	*
11) Triaxial Compression Test	*	*						*			*
12) Compaction Test		*			*					*	
13) Laboratory CBR Test		*			*		*	*	*	*	
14) Standard Penetration Test		*								*	
15) Static Cone Penetration Test		*		*	*		*	*	*		*
16) Field Vane Test											
17) Field CBR Test											
18) Plate Bearing test											
19) Field Permiability Test											
20) Field Unit Weigth Test of Soil											
21) Boring, Drilling											
22) Thin Wall Tube Sampling		*									
III. Experimental Methods in Concrete											

Table 3-4 (2) Actual Activities in Civil Engineeirng Laboratories

Laboratory Practice / University	UNSYIAH	USU	NOMMENSEN	UMA	UDA	UISU	UNAND	UNSRI	UNILA	UNTAN	UNLAM
1) Test for Specific Gravity of Cement	*	*	*	*		*	*				
2) Test for Fineness of Cement	*	*		*		*	*				
3) Test for Setting Timen of Cement	*	*		*		*	*				
4) Test for Soundness of Cement	*	*		*		*	*				
5) Test for Strength of Cement	*	*		*		*	*				
6) Test for Sieve Analysis	*	*		*		*	*			*	*
7) Test for Specific Gravity and Absoption of Fine Aggregate	*	*								*	*
8) Test for Specific Gravity and Absorption of Coarse Aggregate	*	*								*	*
9) Test for Unit Wight and Solid Volume Percentage		*		*						*	*
10) Test for Surface Moisturer		*									
11) Slump Test	*	*	*	*	*	*	*		*	*	*
12) Test for Air Content in Fresh Concrete	*	*		*		*					
13) Test for Compressive Strength of Concrete	*	*		*	*	*	*				
14) Test for Splitting Tensile Strength of Concrete	*	*				*					
15) test for Flexural Strength of Concrete	*	*				*			*	*	*
16) Design for Mix Preportion	*	*	*	*	*	*	*		*	*	*
17) Test for Abrasion of Coarsed Aggregate					*						
IV. Experimental methods in Hydraulics											
1) Stability of Floating Body											
2) Calibration of V-notch Weir	*										
3) Experiment on Venturimeter	*										
4) Laminar Flow and turbulant Flow	*										
5) Subcritical flow Supercritical Flow and Hydraulics Jump	*										
6) Discharge at Gate											
7) Friction Loss of Pipe Flow	*										
8) Sedimentation of Particle											
9) Experiment on Orifice	*										
10) Elocity Distribution of Pipe Flow											
11) Energy Loss Due to Sudden Contraction and Expansion in Pipe Flow	*										
12) Velocity Distribution of Open Channel Flow										*	
13) Uniform and Nonuniform Flwow of Open Chnnel										*	*

Table 3-4 (3) Actual Activities in Civil Engineeirng Laboratories

Laboratory Practice / University	UNSYIAH	USU	NOMMENSEN	UMA	UDA	UISU	UNAND	UNSRI	UNILA	UNTAN	UNLAM
14) Experiment on Waves	*										
15) Field Survey on River Discharge											
16)									*	*	
17) Experiment on Dam Hydraulics										*	
V. Experimental Methods in Transportation Engineerng											
1) Penetration Test for Asphalt											
2) Softening Point Test for Asphalt											
3) Ductility test for Asphalt											
4) Flash Point Test for Aspahlt											
5) Engler Specific Viscosity Test											
6) Resistance Plastic Flow test Using Marshall Appratus											
7) Test for Bitumenn Content of Paving Mixture											
8) Desigh for Mix Proportion of Asphalt Mixtures											
9) Test fot Abrasion of Coarse Aggregate											
10) Test for Splitting Strength of Concrete											
11) Test for Flexural Strength of Concrete											
12) Laboratory CBR Test											
13) Field CBR Test											
14) Plate Bearing Capacity Test											

Table 3-5 (1) Details of Model Mechanical Engineering Laboratory Activities

	Experimental subject	Purpose and contents of experiment	Main experimental equipment
Fluid machinery experiment	Measurement of fluid delivery rate	Students should understand the structure of orifice-meter and learn how to measure the fluid delivery rate, and induce a experimetal equation through the experiments.	Orifice-meter, manometer water-tank, weigthing machine, large bucket, stop-watch, thermometer, scale, slide calipers, manometers, a set of pipe lines
	Measurement of Pressure loss in a pipe	Students should measure the pressure loss in the straight pipe or the head loss due to deflection of the pipe, and understand the meaning of the head loss, when a fluid flows in a pipe.	equipment for measurement of pressure loss in the pipe, manometer, water-tank, weighing machine, large bucket, stop-watch, thermometer, a set of tools for setting pipe, equipment for measurement of elbow loss of pipe
	Performance test of centrifugal pump	Students should operate a pump and examine its performans. An operating characteristic of pump has to be examined.	Pump, a set of water channel, 3 phases induction motor, triangular notch weir, hook gauge, pressure gauge, vacuum gauge, volt meter, ammeter watt meter, tachometer
	Performance test of Francis turbine	Theoritical power, net power and comparative rotating speed have to be measured. Students should understand the characteristics of the turbine	Francis hydrauric turbine, water supply pump, equipment for measurement of fluid delivery rate, dynamo meter, weighing machine, tachometer
	Performance test of air blower (multi blade fan)	Students should operate multi blade fan and examine the change of the performance of the fan when air capacity is changed. They should learn how to operate the multi blade fan.	Experimental set of multi blade fan, manometer, inclimation manometer pitot pipe, tachometer, psychrometer, pressure gauge, volt meter ammeter, watt meter.
	Small experimental wind tunnel	Resistance and disturbance of air flow (disturbance of flow line) have to be examined in the case which various kinds of the resistances are existed in air flow.	A set of experimental wind tunnel, manometer, pitot pipe, thermometer, stop-watch, scale, various kinds of resistance models, Psychrometer,
Performance test of internal comburstion engine	Costant rotating speed	Students should learn the operation of internal combustion engine when an engine is used under constant rotating spped. And they should examine the performance of the engine under each condition of full, over, and partial load.	Water cooled constant speed internal combustion engine, Junkers water-dynamo meter, weighing machine for dynamo meter, tachometer, measruing instrument for fuel consumption, stop-watch, thermometer, pressure gauge, psychrometer, density meter, tools for ajusting engine, thermo couple
	Constant load	Students should learn the opration of internal combustion engine which is operated with variable speeds such as automobile engine, and examine the performance of engine under each condition of full and partial load when rotating speed of the engine is changed.	Water cooled internal combustion engine electric dynamometer, techometer, milivolt meter for thermocuple, tools for ajusting engine thremometer, pressure gauge, equipemt for adjusting engine, thermometer, pressure gauge equipment for measurement of fuel consumption, density meter, stop-watch, vacuum meter, D.C. volt meter, D.C. ammeter, sliding type
Electical experiment	Experiments for applying Chm's law and kirchhoff's law or RLC circuit experiment	Students should measure the resistance by fall-of potential method. After understanding kirchhoff's law, they should compare measuring valves with calculated valves in a complex circuit composed by more than two closed circuits	resistor, buttery, resistance, switch

Table 3-5 (2) Details of Model Mechanical Engineering Laboratory Activities

	Experimental subject	Purpose and contents of experiment	Main experimental equipment
	Measurement of a resistance by using wheatstone bridge	Students should understand the principle of wheatstone bridge and measure various kinds of resistances by using it.	wheatstone bridge, galvanometer, sliding type resistor, resistance dry cell, switch
	Special chracteristic test of 3 phase induction motor	Students should measure each valve of the characteristics of 3 phases induction motor in a case which D.C. generator is loaded and calibrate their valves by loss-separation method they should understand the load characteristic and the speed characteristic etc. of 3 phases induction motor.	(1) equipment for measurement of 3 phases induciton motor, D.C. voltmeter, D.C. ammeter thermometer, sliding type resistor (2) non-load test 3 phase induction motor, A.C. ammeter, watt meter [2], frequency meter, short circuit switch [5], 3 phase induction voltage regulator, switch (3) Load test 3 phase induction motor, A.C. volt meter, A.C. ammeter watt meter [2], frequency meter 3 phase induction voltage regulator, D.C. generator, D.C. voltmeter, D.C. ammeter [2] magnetic-field resistor, load resistor, short-circuit switch [5], switch
	Observation of wave shape and loop due to Braun tube oscilloscope	Students should learn how to use Braun tube oscilloscope and observe vqarious kinds of wave shapes and loops.	Braun tube oscilloscope (synchoscope), frequence generator (signal generator)
Air conditioning and refrigeration experiments	Heat transfer experiment	Students should measure heat-distribution of a material having temprature gradient and compare the results with the value of theorirtical caluculation, they should determines a heat transfer coefficient of the material.	a set of experimental equipment, thermo couple [5], milli volt meter, cold junction, adiabatic material
	Refrigeration experiment	Students should learn the basic principle of air conditioning and refrigeration and do the principle and operation of a system of air conditioning.	experimental refrigerator, thermocouple [5], milli volt meter cold junction, adiabatic material
	Measurement of heat-quantity	Students should measure specific heat and heat capacity of materials by means of calorietry	Calorimeter, millivolt meter for thermocuple [3] adiabatic material constant temperature bath adia
Material experiment	Measurement of hardness brinnell hardness vickers hardeness	Students should understand the principles and functions of Brinmell hardness tester and Vickers hardness tester and learn how to make specimens for measuring hardness.	Brinnell hardness tester, measurement microscope, specimen (mild steel), Vickers hardness tester, various metal specimen cutting specimen machine, a set of polishing machine
	Tensile and compressive tests	Student should examine the mechanical properties of materials such as tensile strength, yield point, elongation and shear strength and learn how to operate a testing machine. Also, they should learn how to make the specimen.	Universal tensile machine, V block (chuck), micrometer, side calipers, marking-off pin, hammer, specimen, paper for automatic record, load cell
	Bending test	Students should understant that this is important in industry to know the strength and the workability of metal.	universal tensile machine, V block (chuck), side calipers, marking-off pin, specimen, scale, paper for automative record load cell

Table 3-5 (3) Details of Model Mechanical Engineering Laboratory Activities

	Experimental subject	Purpose and contents of experiment	Main experimental equipment
	Chalpy impact test	Students should understand the principle of impact test, and do the meaning of ductaile-brittle transition of mild steel.	Chalpy impact testing machine, gauge, side calipers, micrometer, specimen, temperature (low temperature) rack, specimen for ceps.
	Observation of micro-structure of metal	Studendt should learn the structure and the funtion of microscope for metals and photographic equipment, and learn how to make the specimens.	microscope for metals, photographic equipment for microscope, specimen, polishing machine, powder for polishing, etching egent,
	Experiment of working for metals	Students should practice the techniques of working for metals such as rolling and foreging.	small rolling machine, small foreging machine side calipers micro meter, small furnace (800 ℃) specimen forcops.
Machine total experiment	Operation of lathe, milling machine and drilling machine etc.	Students should practice how to operate machine tools.	lathe, milling machine, drilling machine, chopper machine, sawing machine, grinder, a set of tools.
Measurment	Calibration of micrometer by using block gauge	Students should learn the calibrtation of the scale of micrometer and the inspection method for knowing accuracy of micrometer by using block gauge. They should learn how to use block gauge.	micrometer, micrometer stand, block gauge, volatile oil, benzine, gasoline, gauge, washing bath
	Measurment of Pitch of screw by tool maker's microscope	Students should understand the principal and the structure of tool maker's microscope and measure a pitch and a effective of a parallel make screw.	tool maker's microscope, parallel make screw etc.
Machine elements design	Machine elements, basic design	Drawing and calculation of strength of machine elements should be studied.	drawing instrument, machine elements model.
Welding Practice	Practice of welding of stainless steel	Studnets should practice to weld sheet and pipe stainless steel and observe in the welding part.	D.C. are welding machine, cord reel, volt meter, ammeter transformer, stainless steel sheet, pipe, eye glass, hammer, acid washing bath, welding electrode, drying oven, equipment for examining the welding part.
	Practice of spot welding of various metals	Students should learn the technique for spot welding of metal sheet and wire.	spot welding machine, volt meter, ammeter, transformer, specimen sheet, equipments for examining the structure of welding part.

Table 3-6 Actural Activities in Mechanicla Engineering Laboratories

Course	UNSYIAH	USU	UMA	UDA	UISU	UNAND	UNSRI	NOMMENSEN
I. Fluid machinery experiment								
(1) Measurement of fluid delivery rate		*	*		*	*		*
(2) Measurement of wearing loss		*	*		*	*		*
(3) Pump performance	*	*	*	*	*	*	*	*
(4) Turbine perofrmance		*	*	*			*	*
(5) Air blower performance		*						*
(6) Small wind tunnel experiment		*	*					*
(7) Compressor performance	*						*	*
II. Internal combustion engine								
(1) Decomposition and composition	*		*				*	
(2) Material examination of engine						*		
(3) Engine performance		*	*				*	*
- Constant speed of rotation								
(4) Engine performance		*	*				*	*
- Constant load								
(5) Gas turbine performance								*
III. Drawing, Machine elements								
(1) Design & Drawing	*	*	*	*	*	*	*	*
(2) Machine elements	*	*	*	*	*	*	*	*
IV. Material experiment								
(1) Tensile and compression test	*	*	*		*	*		*
(2) Bending test	*	*	*	*	*			*
(3) Buckling test	*	*				*		
(4) Hardness measurement	*		*	*	*	*		
(5) Casting experiment								
(a) Sand mould maching								
(b) Melting, Casting								
(6) Examination of micro-structure		*	*	*	*	*		
(7) Examination of ductile-brittle transition (Chaply impact test)	*	*	*		*	*		
(8) Corrosion test						*		
V. Thermodynamics experiment								
(1) Calorimetry				*		*		*
VI. Heat transfer and refrigeration air conditioning experiment								
(1) Adiabatic sahirator experiment		*		*		*		
(2) Refrigerator performance				*		*	*	
VII. Welding Practice								
(1) Welding of stainless steel							*	
(2) Acetylene gas welding	*							*
(3) Spot welding	*	*	*		*		*	*
VIII. Welding practice								
(1) Calibration test of micrometer	*	*	*		*	*		
(2) Tool maker's microscope test								
(3) Measurement of vibration	*							
XI. Practice of machine tool								
(1) Practice of lathe	*	*	*	*	*	*	*	*
(2) Practice of drilling machine and shaper	*	*		*		*	*	*
(3) Practice of filing and polishing (scraping)	*	*	*	*	*	*	*	*

Table 3-7 (1)
Details of Model Electrical Engineering Laboratory

ITEM	PURPOSE	MAJOR EQUIPMENT
1. ELECTRICITY		
1.1 Voltmeter	use of voltmeter	A.C.voltmeters, D.C.voltmeters, batteries, switches, standard variable resistor, lamps
1.2 Ammeter	use of ammeter	D.C.ammeters, A.C.Ammeters, fixed resistors, shunt, batteries, loads, switches
1.3 Resistor	use of various resistors	D.C.voltmeter, D.C.milliammeter, fixed resistor, batteries, switches, various kinds of resistors
1.4 Circuit Tester	measurement of D.C.voltage, D.C.current, A.C.voltage, resistance etc. using a circuit tester	circuit testers, batteries, slidac, various kinds of resistors, diodes, electrolytic capacitor
1.5 Ohm's Law		D.C.milliammeter, D.C.voltmeter, slide reostat, D.C.power source, switches, fixed and variable resistors
1.6 Kirchhoff's Law		D.C.ammeters, rheostats, batteries, switches, circuit tester
1.7 Characteristics test of a dry cell	measurement of the internal resistance and the characteristics of dry cell	D.C.voltmeter, load resistor, dry cell, switches, stopwatch
1.8 Pointer type galvanometer	measurement of the sensitivity of a pointer type galvanometer	galvanometer, D.C.voltmeter, high resistor, battery, variable resistor, switches, stopwatch
1.9 Measurement of resistance by the drop method	measurement of resistance using a galvanometer and ammeter	D.C.power source, D.C.voltmeter, D.C.ammeter slide rheostat, switches, resistors
1.10 Measurement of resistance by the drop method	measurement of resistance using a galvanometer and a known resistance	pointer type galvanometer, slide rheostats, universal shunt, battery, switches
1.11 Measurement of resistance by the equal deflection method	measurement of the resistance of a galvanometer	galvanometer, slide rheostat, standard resistors, battery, switches

Table 3-7 (2)
Details of Model Electrical Engineering Laboratory

ITEM	PURPOSE	MAJOR EQUIPMENT
1.12 Measurement of resistance by the Wheatstone bridge		PO box, galvanometer, universal shunt, battery, multimeter, fixed resistors, low frequency choking coil
1.13 Measurement of the resistance of a galvanometer by the Kelvin method	measurement of the resistance of a galvanometer using a Wheatshone bridge	galvanometer, slide rheostats, batteries, switches, Wheatstone bridge
1.14 Measurement of resistance using the Kelvin double bridge	measurement of resistivity by the Kelvin double bridge method	D.C.ammeter, rheostat, battery, switches, Kelvin double bridge, micrometer
1.15 Measurment of the resistance of electrolyte by the Khol-rausch bridge		Kohlrausch's bridge, U type tube, water tank, thermometer, electric heater, electrolyte
1.16 Measurement of earthing resistance by the Kholrausch bridge		earthplate, auxiliary earthpole, Kohlrausch bridge
1.17 Measurement of insulation resistance by the megger	measurement of the insulation resistance of electric equipment and interior wiring	megger, transformer, interior wiring
1.18 Measurement of insulation resistance by the mirror galvanometer	measurement of the resistance of insultated wire by the direct deflection method	mirror galvanometer, D.C.voltmeter, D.C.power source, rheostat, universal shunt, insultated wire, switches
1.19 Measurement of the constants of the ballistic galvanometer		ballistic galvanometer, rheostat, mutual inductance, D.C.milliammeter, slide rheostat, switches, battery, stopwatch
1.20 Calibration of D.C.meters		standard D.C. meters, D.C.voltmeters and ammeters to be calibrated, shunt, rhostat, switches, D.C.power source
1.21 Measurement of the electromotive force of a battery using the potentiometer		battery, standard cell, power supply battery, pointer type galvanometer, shunt, resistor to adjust the supply voltage, resistor to protect the standard cell, D.C.ammeter, switches, D.C.potentiometer, volt box

Table 3-7 (3)
Details of Model Electrical Engineering Laboratory

ITEM	PURPOSE	MAJOR EQUIPMENT
1.22 Calibration of an ammeter and a voltmeter using the potentiometer		ammeter, voltmeter, D.C.power supply, standard cell, D.C.ammeter, pointer type galvanometer, standard resistor, rheostat, shunt, D.C.potentiometer, volt box switches
1.23 Measurement of the characteristics of the thermocouple	measurement of the thermo-electromotive force of a	thermocupple, slidac, electric furnace, thermostat, switches, D.C.millivoltmeter, thermometer, watches
1.24 Measurement of the charge-discharge characteristics of the storage battery	measurement of the charge and discharge characteristics of a lead storage battery	storage battery, D.C.voltmeter, D.C.ammeter, rheostat, densitometer, switches, thermometer
1.25 Measurement of electrochemical equivalent using the voltmeter		voltmeter, D.C.ammeter, storage battery, rheostat, switches, sulfuric acid, alchol, chemical balance, copper sulfate, beaker
1.26 Measurement of capacitance and inductance using an A.C.bridge	Principle of the A.C. bridge and measurement of L and C	inductance, capacitor, variable standard inductance, variable standard capacitor, low frequency oscillator, receiver, keys, A.C.bridge
1.27 Use of the Oscilloscope	observation of A.C.wave forms	oscilloscope, slidac, signal generator, circuit tester, vacuum tube voltmeter, circuit to operate an oscilloscope
1.28 Measurement of L and C by the potential drop method	measurement of L and C by the potential drop method. characteristics of iron-core inductance	iron-core inductance, air-core coil, capacitor, standard rheostat, A.C.voltmeter, A.C.ammeter, slidac, switches
1.29 Measurement of one-phase electric power	measurement of one-phase electric power by three methods; one-phase wattmeter method, three ammeters method, three voltmeters method	one-phase wattmeter, A.C.ammeters, A.C.voltmeters, standard, rheostat, variable reactor, lamp, switches
1.30 Measurement of three-phase electric power	measurement of three-phase electric power by the two wattmeters method	one-phase wattmeter, three-phase wattmeter, A.C.ammeter, A.C.voltmeters, switches, balanced three-phase load, induction voltage regulator

Table 3-7 (4)
Details of Model Electrical Engineering Laboratory

ITEM	PURPOSE	MAJOR EQUIPMENT
1.31 Characteristic measurement of the integrating wattmeter		one-phase integrating wattmeter, one-phase wattmeter, A.C.voltmeter, A.C.ammeter, load resistor, variable reactor, slidac, switches, stopwatch
1.32 Hysteresis loop	measurement of the magnetic hysteresis of a ring type iron-core using a flux meter	flux meter, D.C. ammeter, A.C.ammeter slidac, switches, slide rheostat, storage battery, iron cores
1.33 Measurement of iron loss by the Epstein appratus	measurement of iron loss using the epstein apparatus and the magnetization curve of magnetic materials	A.C.voltmeters, A.C.ammeter, wattmeter, frequency meter, mutual inductance, slidac, switches, Epstein apparatus, seight scale, magnetic materials
1.34 Efficiency test of an electric heater		beaker, thermometer, A.C.ammeter, A.C. voltmeter, slidac, switches, wattmeter, integrating wattmeter, electric heater
1.35 Measurement of the characteristics of fuse	relation between fusing current and fusing time	A.C.ammeter, cycle counter, rheostat, lamp, switches, micrometer, balance, stopwatch, fuses
1.36 Observation of wave forms by the electromagnetic oscillograph		battery, D.C.milliammeter, rheostat, switches, electromagnetic oscillograph, slidac, A.C.voltmeter, A.C.ammeter, iron-core inductance
1.37 Measurement of the four terminal network constant		for the D.C.circuit-battery, D.C.voltmeters, D.C. ammeters, resistors in the four terminal network, switches for the A.C.circuit-slidac, A.C.voltmeters, A.C. ammeters, switches, transformer, fixed resistors, dual trace oscilloscope
2. ELECTRIC MACHINES		
2.1 Measurement of a turn ratio of a one-phase transformer and its polarity test		one-phase transformers, A.C.voltmeters, fuse holder, knife switches

Table 3-7 (5)
Details of Model Electrical Engineering Laboratory

ITEM	PURPOSE	MAJOR EQUIPMENT
2.2 No load test of a one phase transformer	no-load loss of a transformer. measurement of exciting current. calculation of excitation admittance	one-phase transformer, one-phase induction voltage regulator, one-phase wattmeter, rheostat, A.C. voltmeter, A.C.ammeter, D.C.voltmeter, D.C.ammeter, knife switch
2.3 Short circuit test of a one-phase transformer	measurement of the load loss and the impedance voltage of a transformer. calculation of the percent impedance. Voltage regulation and conventional efficiency	one-phase transformer, one-phase induction voltage regulator, one-phase wattmeter, A.C.ammeter, A.C.voltmeter, knifeswitch, thermometer
2.4 Load test of a one-phase transformer	measurement of the input power and output power with load. measurement of the voltage regulation and efficiency	one-phase transformers,one-phase wattmeter, A.C.votmeter, A.C.ammeter, induction voltage regulator, one-phase load apparatus
2.5 Three-phase connection of one-phase transformer	various methods of three-phase connection. relation of the phase voltage and the line voltage	one-phase transformers, voltage regulators, A.C.voltmeters, A.C.ammeters, one-phase wattmeters, megger, D.C.voltmeter, D.C.ammeter, thermometer
2.6 Temperature rise test of a transformer by the loading back method		one-phase transformers, voltage regulators, A.C.voltmeters, A.C.ammeters, one-phase wattmeters, megger, D.C.voltmeter, D.C.ammeter, thermometer
2.7 Other connections of transformers	six-phase connection. T-connection. Relation of the phase voltage and the line voltage	one-phase transformers, A.C.voltmeter, load apparatus, electromagnetic oscillograph
2.8 Starting test of a three-phase induction motor	starting characteristics of a three-phase induction motor	cage-type induction motors, wourd-rotor induction motor, synchroscope, starting compensator, Y-delta switch, resistors, A.C.voltmeters, A.C.ammeters, shunt
2.9 Drawing of a circle diagram of the three-phase induction motor	drawing method of circle diagram. measurement and computation of the characteristics to draw a circle diagram	three-phase induction motor, one-phase wattmeters, A.C.voltmeter, A.C.ammeter, frequency meter, three-phase induction voltage regulator, D.C.ammeter, D.C.voltmeter, resistor, thermometers

Table 3-7 (6)
Details of Model Electrical Engineering Laboratory

ITEM	PURPOSE	MAJOR EQUIPMENT
2.10 Load test of the three-phase induction motor using the electric dynamometer		three-phase induction motor, electric dynamometer, three-phase induction voltage regulator, A.C.voltmeter, A.C.ammeter, three-phase wattmeter, D.C.ammeter, tachometer
2.11 Characteristics test of a one-phase induction voltage regulator	no-load and short-circuit test of a one-phase induction voltage regulator	one-phase induction voltage regulators, one-phase wattmeters, A.C.voltmeters, A.C.ammeters, frequency meter
2.12 Starting test of a D.C.moter	starting cahracteristics, construction features of a starting apparatus	D.C.shunt motor, starter, field regulator, tachometer, D.C. ammeters, D.C.voltmeter, synchroscope
2.13 Speed control of a D.C.motor	advantages and disadvantage of various speed control methods	D.C.motor, D.C.generator, three-phase induction motor, starter, field regulator, armature series resistor, D.C.voltmeters, D.C.ammeters, A.C.ammeter. A.C.voltmeter, tachometer
2.14 Load characteristics test of a D.C.motor	vertification of torque and efficiency by rotation speed	D.C.motor-generator, starter, field regulators, tachometer, D.C.voltmeters, D.C.ammeters load resistor
2.15 No-load characteristics test of a D.C.generator	relation of the current and the induced electromotive force in D.C.generator. relation between rotation speed and induced electromotive force	D.C. motor-generator, starter, field regulators, tachometer, D.C.voltmeter, D.C.ammeter
2.16 Load characteristics of a D.C.generator	measurement of the terminal voltages vs the load currents	D.C.motor-generator, field regulators, starter, D.C.voltmeters, D.C. ammeters, tachometer, load resistors
2.17 No-load test of a three-phase synchronous generator	no-load and short-circuit test of a three-phase synchronous generator. synchronous impedance. short-circuit ratio. voltage regulation	D.C.three-phase synchronous motor-generator, field regulators, starter, D.C. voltmeters, D.C.ammeters, A.C.voltmeter, A.C. ammeters, frequency, meter, tachometer
2.18 Load test of a three-phase synchronous generator	load test. calculation of the efficiency and voltage regulation	D.C.three-phase synchronous motor-generator, field regulators, starter,three-phase load apparatus, D.C. voltmeters, D.C.ammeters, A.C.voltmeter, A.C.ammeter, three-phase wattmeter, three-phase power-factor meter, frequency meter

Table 3-7 (7)
Details of Model Electrical Engineering Laboratory

ITEM	PURPOSE	MAJOR EQUIPMENT
2.19 Parallel running of three-phase synchromous generator	theory of parallel running of synchronous generators. synchronization. load sharing	three-phase synchronous motor-generator, starter, field regulators, synchronism indicator, A.C.voltmeter, frequency meter, three-phase wattmeter, three-phase power-factor meter, A.C.ammeter, D.C.voltmeter, D.C.ammeter, phase meter
2.20 Starting test and characteristics test of a three-phase synchronous motor	operation of a three-phase synchronous motor. phase character, load character	three-phase synchromous motor with D.C.generator, starting compensator, field regulators, load apparatus. three-phase wattmeter, three-phase power-factor meter, A.C.voltmeter, A.C.ammeter, frequency meter, D.C.voltmeter, D.C.ammeters
2.21 Characteristics test of a three-phase shunt commutator motor		three-phase shunt commutator motor, electric dynamometer, field regulator, A.C.voltmeter, three-phase wattmeter, three-phase power-factor meter, A.C.ammeter, D.C.ammeters, tachometer, spring balance
2.22 Thyristor	silicon controlled rectifier, principle of rectifier, constructions, characteristics	thyristor, synchroscope, three-phase wattmeter, A.C.voltmeters, A.C. ammeters, D.C. voltermeter, D.C.ammeter, load apparatus
2.23 Automatic voltage adjustment of a D.C.generator using the amplidyne		amplidyne, D.C.motor-generator, D.C.stabilizing power supply, D.C.ammeters, D.C.voltmeter, tachometer, electromagnetic oscillograph, voltage setting comparison apparatus
2.24 Automatic voltage Adjustment of a D.C.generator using thyristors	automatic adjustment of the output voltage of a D.C.genrator using the thyristor and the magnetic amplifier	D.C.motor-generator, thyristor automatic voltage regulator, electromagnetic oscillograph, synchroscope, D.C.voltmeter, D.C.ammeter, tachometer
2.25 Automatic Speed control of the VS motor	construction and characteristics of the VS motor. principle of automatic speed control	VS motor, VS motor control system, electric dynamometer, three-phase wattmeter, A.C.voltmeter, A.C.ammeter, D.C.ammeter, electromagnetic oscillograph

Table 3-7 (8)
Details of Model Electrical Engineering Laboratory

ITEM	PURPOSE	MAJOR EQUIPMENT
2.26 Automatic operation of a motor by the sequence control	sequence control	three-phase induction motor, electromagnetic contactors, push-button switches, timing relay, auxiliary relay
3. HIGH VOLTAGE		
3.1 High voltage experiment	high voltage test of electric equipment and facilities	high voltage testing device
3.2 Sparking discharge test	Graduation of a voltmeter using the sphere gap. relation betwen the discharge voltage, the gap length and electrode shapes	high voltage testing device, stardard sphere gap, bar gap, disc electrode, electrostatic voltmeter, A.C.voltmeter
3.3 Breakdown test	breakdown test methods of insulating materials and insulating oil. insulating characteristics of materials	high voltage generator, insulating material testing equipment, insulating oil withstand voltage testing device, A.C.voltmeter, electrostatic voltmeter A.C.ammeter
3.4 Impulse voltage generator	operation of an impulse voltage generator. starting characteristics. measurement of the utilization factor and the output characteristics	A.C.high voltage generator, high voltage rectifier, impulse voltage generator, control panel. speed triggered sweep Brown tube-oscilloscope, klydonograph
3.5 Insulator test	dry flashover voltage test impulse flashover voltage test	A.C.high voltage testing device, implulse voltage generator, high speed triggered sweep Brown tube oscillograph, insultators
4. TRANSMITTION AND DISTRIBUTION		
4.1 Relays	the construction features of the inductive overcurrent relay and its testing method	A.C.ammeter, A.C.voltmeter, frequency meter, cycle counter, load resistor, switches
4.2 Characteristics measurement of the transmission line using imitated transmission line	measurement of the circuit constants and the characteristics of a transmission line	A.C.voltmeters, ammeters, one-phase wattmeter, slidacs, power-factor line, switches, power factor regulation load appratus, artificial transmission line device

Table 3-7 (9)
Details of Model Electrical Engineering Laboratory

ITEM	PURPOSE	MAJOR EQUIPMENT
5. LIGHTING		
5.1 Voltage characteristics of incandecent light	relation among the light intensity, power consumption, current, resistance and voltage	D.C.voltmeters, D.C.ammeters, slide rheostat, voltage divider, photometer
5.2 Characteristics of fluorescent lamps		wattmeter, A.C.voltmeters, A.C.ammeter, slidac, variable capacitor, stabilizer, glow lamp, switch, capacitor for limiting noise, fluorescent lamps
5.3 Measurement of illumination intensity		illuminometer
5.4 Measurement of the light intensity and the distribution curve of light		photometer, D.C.voltmeters, D.C.ammeters, slidac rheostat, voltage divider, standard lamp, switches
5.5 Measurement of the light flux using a light-flux meter		D.C.voltmeters, D.C. ammeters, rheostats, sphere type flux meter, standard lamp, lamp for comparison
6. ELECTRONICS		
6.1 Electronic refrigeration	characteristics of the electronic refrigeration elements and the power supply	power supply device, thermoelectric elements
6.2 High frequency inductive heating	principle of the inductive heating. operation of a high frequency heating device	high frequency inductive heater, shore durometer, beaker, thermometer
6.3 Characteristics of the vacuum tube voltmeter	measurement of the sensitivity and frequency characteristics of a vacuum tube voltmeter	various vacuum tube voltmeters, A.C.voltmeter, slidac, standard signal generator, low frequency oscillator, switches, fixed resistor
6.4 Measurement of circuit constants in a high frequency range using Q meter	principle of Q meter	Q meter, LCR meter, coils, capacitors
6.5 Static characteristics of vacuum diode		D.C.ammeters, D.C.voltmeters, eliminators, slide rheostats, switches, vacuum diodes

Table 3-7 (10)
Details of Model Electrical Engineering Laboratory

ITEM	PURPOSE	MAJOR EQUIPMENT
6.6 Static characteristics of triode		D.C.ammeters D.C.voltmeters eliminators, slide rheostats, switches, triodes
6.7 Static characteristics of tetrode and pentode	measurement of the static characteristics of tetrode and pentode. function of a screen grid and a suppressor grid	D.C.voltmeters, D.C.ammeters, eliminators, slide rheostats, switches, tetrodes, pentodes
6.8 Characteristics of discharge tube	measurment of the characteristics of a voltage regulator tube and thyratron	voltage regulator tube, thyratron, D.C.voltmeters, D.C.ammeters, slide rheostats, eliminators, switches, fixed resistors
6.9 Static characteristics of photo tube	measurement of the relation between the incident light flux and the photo current	standard lamp, D.C. voltmeter, A.C.voltmeter, D.C.microammeter, slide rheostat, eliminator, slidac, switches, fixed resistors, photo tubes
6.10 Characteristics of diode	measurement of the characteristics of the silcon and germanium diode (point contact and junction)	D.C.voltmeter, D.C.ammeters, D.C.power supply, slide rheostat, switches
6.11 Characteristics of thermistor and varistor		D.C.voltmeter, D.C.ammters, batteries, slide rheostat, galvanometer, electric heater, wheatshone bridge, switches, slidac, beaker, thermometer, thermistor varistor
6.12 Static Characteristics of transistor		D.C.voltmeters, D.C.ammeters, batteries, slide rheostat, switches, transistors
6.13 Synchroscope		synchroscope, slidac, signal generator, pulse generator, D.C.voltmeter, A.C.voltmeter, vacuum tube voltmeter, battery, fixed resistors, capacitors, slide rheostat
6.14 Measurement of vacuum tube constants	measurement of vacuum tube constants using a A.C.bridge	low frequency oscillaor, eliminators, slide rheostats, D.C.voltmeters, D.C.ammeter, wave detector, mutual inductor, various resistors

Table 3-7 (11)
Details of Model Electrical Engineering Laboratory

ITEM	PURPOSE	MAJOR EQUIPMENT
6.15 H parameter of transistor		low frequency oscillator, D.C.voltmeters, D.C.milliammeter, vacuum tube voltmeters, eliminators, slide rheostats, resistors, transistor tester, transistors
6.16 Measurement of the static characteristics of the SCR	static characteristics of the silicon controlled rectifier	SCR, D.C.power supplies, low frequency oscillator, D.C.voltmeters, D.C.miliammeters, slide rheostats, resistors, variable resistors, sychroscope, circuit tester, change-over switches
6.17 Characteristics of the low frequency voltage amplification circuit using vacuum tube	measurement of the characteristics of low frequency voltage amplifiers using vacuum tubes (resistance amplifiers tranformer-coupled amplifiers, chalk-capacitor coupled amplifiers)	amplifiers, eliminators, variable resistance attenuator, low frequency oscillator, vacuum tube voltmeter, synchroscope, fixed resistors, capacitors, low frequency choking coil, change-over switches, circuit tester, phase meter
6.18 Characteristics of the low frequency voltage amplifiers using transistor	measurement of the characteristics of low frequency voltage amplifiers using transistors (resistance amplifiers, transformer-coupled amplifiers)	amplifiers, battery, variable resistance attenuator, low frequency oscillator, vacuum tube voltmeter, synchroscope, change-over switches, circuit tester, fixed resistor
6.19 Characteristics of the negative feed-back amplifier		amplifiers, low frequency oscillator, variable resistance attenuator, vacuum tube voltmeter, synchroscope, circuit tester, fixed resistors, capacitor, change-over switches
6.20 Characteristics of the low frequency power amplifiers using vacuum tubes	measurement of the optimum conditions of the vacuum tube power amplifiers and calculation of the efficiency	amplifiers, eliminators, vacuum tube voltmeters, D.C.voltmeters, D.C.ammter, low frequency oscillator, output transformer,circuit tester, rheostat, synchroscope, wattmeter
6.21 Characteristics of the low frequency power amplifiers using transistors	measurment of the optimum conditions of the transistor power amplifiers and their characteristics	amplifier, D.C.voltmeter, vacuum tube voltmeters, D.C.ammeters, rheostat, low frequency oscillator, output transformer, battery, synchroscope

Table 3-7 (12)
Details of Model Electrical Engineering Laboratory

ITEM	PURPOSE	MAJOR EQUIPMENT
6.22 Characteristics of the vacuum tube medium frequency amplifiers		amplifer signal generator, input impedance, load resistor, synchroscope, eliminator
6.23 Characteristics of the vacuum tube high frequency amplifiers		high frequency amplifier, signal generator, vacuum tube voltmeter, eliminator, capacitors, circuit tester
6.24 Wide band amplifiers		amplifier, eliminator, low frequency oscillator, signal generator, pulse generator, synchroscope, variable resistance attenuator, change-over switches, high frequency chalking coils, capacitors, fixed resistors
6.25 Transistor video frequency amplifiers	measurement of the characteristics of the transistor video frequency amplifiers and the emitter follower amplifier	video frequency amplifier, signal generator, vacuum tube voltmeter, synchroscope, fixed resistor, capacitor
6.26 Characteristics of the D.C. amplifier		amplifier, D.C.voltmeters, batteries, D.C.vacuum tube voltmeter, eliminator, D.C.ammeter, slidac, A.C.voltmeter, slide rheostat
6.27 Characteristics of the back-coupling oscillator	measurement of the characteristics of the Hartley circuit	back-coupling oscillator, eliminator, D.C.voltmeters, D.C.ammeter, high frequency fixed resistors, battery, switches, signal generator, wave detector, synchroscope, high frequency transformers, low frequency transformer
6.28 Characteristics of the CR oscillator	the characteristics of a CR oscillator and the comparison with the back-coupling oscillator	oscillator, eliminator, D.C.voltmeter, rheostats, variabl capacitors, thermister, synchroscope, low frequency oscillator, slidac, A.C.voltmeter
6.29 Measurement of the characteristics of the AM modulation circuit	measuremnt of the carrier, signal wave and modulation percentage	modulator, D.C.voltmeters, D.C.ammeter, eliminators, signal generator, low frequency oscillator, synchroscope, change-over switch, vacuum tube voltmeters

Table 3-7 (13)
Details of Model Electrical Engineering Laboratory

ITEM	PURPOSE	MAJOR EQUIPMENT
6.30 Measurement of the characteristics of the AM detection circuit	diode wave detection, plate detection and grid detection of the AM modulated wave	wave detector, eliminators, signal generator, low frequency oscillator, D.C.voltmeters, capacitors, synchroscope, vacuum tube voltmeters, high frequency amplifier
6.31 Measurement of the characteristics of the FM modulation circuit	measurement of the frequency modulation characteristics of the FM circuit using reactance tubes	modulator, eliminators, D.C.voltmeter, heterodyne wavemeter, synchroscope, capacitors, fixed resistors
6.32 Measurement of the characteristics of the FM demodulation circuit	Foster-Seely circuit, and Ratio circuit	demodulator, signal generator, D.C.vacuum tube voltmeter, micro ampere meter, eliminator, circuit tester, fixed resistors
6.33 Characteristics of a rectifier with smoothing circuit	voltage regulation of a rectifier with smoothing circuit. measurement of ripples and rectification efficiency	rectifier, A.C.voltmeter, A.C.wattmeter, D.C.voltmeter D.C.ammeter, vacuum tube voltmeter, slide rheostat, switches, slidac, synchroscope
6.34 Transient phenomenon of of the RC circuit	measurement of the charge and discharge characteristics of the RC circuit and the application of the RC circuit to a pulse circuit	D.C.power supply, D.C.voltmeter, D.C. microammeters, switches, fixed resistors, capacitors, stopwatch
6.35 Clipper, slicer, clamping circuit, differential circuit, integration circuit	wave shaping circuits	clipper, clamp circuit, differential circuit, integration circuit, battery, D.C.voltmeters, capacitors, fixed resistors, signal generator, non-sinusoidal waves generator, synchroscope
6.36 Measurement of the characteristics of the multivibrator	waveformsat each electrode of a multivibrator and their application to electronics circuits	astable multivibrator (vacuum tube), astable multivibrator (transistor), bistable multivibrator, eliminator, battery, fixed resistors, capacitors, D.C.Voltmeters, D.C.ammeters, synchroscope, amplifier, nonsimusoidal waves generator

Table 3-7 (14)
Details of Model Electrical Engineering Laboratory

ITEM	PURPOSE	MAJOR EQUIPMENT
6.37 Measurement of the characteristics of the saw tooth oscillator	measurement of the characteristics of saw tooth oscillators using discharge tubes	saw tooth oscillator using diode discharge tube, saw-tooth oscillator using thyratron, eliminators, D.C.voltmeters, D.C.milliammeter, nonsinusoidal wave generator, amplifier, capacitors, fixed resistors, synchroscope
6.38 Measurement of the characteristics of the resistance attenuator	understanding of the four terminal network by the measurement of the characteristics of a resistance attenuator	low frequency oscillator, level meter, change-over switch, fixed resistors, high frequency variable resistor
6.39 Measurement of the characteristics of filters	to construct a filter circuit of simple elements and to measure its characteristics	variable induction-box, variable capacitors, low frequency oscillator, variable resistance attenuator, vacuum tube voltmeter, change-over switches load resistor, artificial line (low frequency)
6.40 Analysis of nonsinusoidal waves	to analyze nonsinusoidal waves and to investigate what characteristics of amplifiers are required for nonsinusoidal waves used in electronic circuit	nonsinusoidal waves generator (triangle waves, rectangular wave, pulse wave), variable high pass filter, variable low pass filter, synchroscope, load resistors, Klirrfaktormeter, change-over switch, nonsinusoidal wave circuit
7. TELECOMMUNICATION		
7.1 Measurement of natural frequencies of antenna and antenna constant		antenna, signal generator, heterodyne wavemeter, high frequency ammeter, high frequency transformer, variable high frequency resistor, standard inductances, switch
7.2 Measurement of the characteristics of the Lecher wire	to measure the characteristics of a Lecher wire. to understand the standing wave and the characteristic impedance. to learn about ultrashort waves	ultrashort wave signal generator, loose coupling high frequency transformer, Lecher wire, high frequency ammeter, vacuum tube voltmeter, high frequency variable resistor,

Table 3-7 (15)
Details of Model Electrical Engineering Laboratory

ITEM	PURPOSE	MAJOR EQUIPMENT
7.3 Measurement of the cahracteristics of a loudspeaker	measurement of the characteristic of the cone type dynamic loudspeaker and combination with amplifier	low frequency oscillator, low frequency amplifiers, transformer, loudspeaker, condenser microphone, resistance attenuator, vacuum tube voltmeters, sounder, change-over switch, synchroscope, acoustic experiment equipment
7.4 Characteristics of a receiver	measurement of the noise limiting sensitivity and selectivity of a receiver	receiver, load circuit, artificial antenna, signal generator, change-over switch, high pass filter, band pass filter, level meter, vacuum tube voltmeter, synchroscope
7.5 Transmitter	adjustment of a radio transmitter	radio transmitter, artificial antenna, illuminometer, D.C.power supply, D.C.ammeter, D.C.voltmeter, low pass filter, resistance attenuator, vacuum tube voltmeter, pickup coil, synchroscope, change-over switch, frequency meter
7.6 Relays for communication		relay kit, D.C.ammeter, D.C. power supply, galvanometer, standard variable resistor, standard capacitor, circuit tester, register, synchroscope, electronic counter, oscillograph
7.7 Adjustment of a superheterodyne receiver		superheterodyne receiver, signal generator, synchroscope, circuit tester, vacuum tube voltmeter, capacitors, D.C.ammeter, fixed resistors
7.8 Adjustmet of the television receiver		television receiver, sweep oscillator, oscilloscope, low frequency oscillator, vacuum tube voltmeter, circuit tester, fixed resistor, capacitor, marker generator
7.9 Measurement of ultrashort waves	measurement of the characteristics of the klystron and the standing wave in a microwave circuit	microwave experiment equipment, microampere meter, oscilloscope, amplifier

Table 3-7 (16)
Details of Model Electrical Engineering Laboratory

ITEM	PURPOSE	MAJOR EQUIPMENT
8. CONTROL		
8.1 Analog computer	circuit of an analog computer and programming to solve differential equations	D.C.amplifier, synchroscope, square wave generator, rheostat, fixed resistors, capacitors, analog computer, oscillograph
8.2 Measurement of the indicial response in the temperature sensor and the electric furnace	to understand the transfer function by measuring the characteristics of the equivalent circuits of a temperature sensor and an electric furnace in a automatic control system	thermocouple, electric furnace, A.C.wattmeter, A.C.ammeter, A.C. voltmeter, D.C.amplifier, oscillograph, X-Y recorder, thermometer, slidac
8.3 Characteristic measurement of a differential transformer	characteristic measurement of a differential transformer which is used to detect linear and angular displacement	slidac, differential transformer, vacuum tube voltmeters, synchroscope, micrometer, rheostat, variable capacitor
8.4 Bode diagram of the CR compensation circuit	to understand the transfer function and the stability criterion by drawing the Bode diagram	ulgralow frequency oscillator, oscillograph, fixed resistors, capacitors battery, rheostat
8.5 Characteristic measurement of an A.C. servomotor	measurement of the characteristics of a two-pahse servomotor. servomotor in an automatic control system	servomotor, spring balance, slidac, oscilloscope, stopwatch, A.C.voltmeters, A.C.ammeter, pully, capacitors, fixed resistor
8.6 Characteristic measurement of FET transistor	measurement of the static characteristics of FET transistor using synchroscope	eliminator, vacuum tube voltmeter slide rheostat, synchroscope, low frequency, oscillator, FET transistors, transistor (2SC32A), diode, fixed resistors, switches, D.C.amplifier
8.7 Characteristics of logic circuit		pulse generator, dual trace synchroscope, logic circuit rheostat, battery, switches
8.8 Characteristic measurement of analog IC		compensation amplifier, D.C.power supplies, variable voltage power suplies, switches, input resistors, load resistors, capacitors, signal generator, pulse generator, synchroscope
8.9 Characteristic measurement of digital IC		pulse generators, eliminators, synchroscope, milliammeter, D.C. voltmeter, thermostat, thremometer, 2OR-2AND, DTL 3-input NAND gate (TD 1001M) operational amplifier

Table 3-8 (1) Actual Activities in Electrical Engineering Laboratories

Theme	USU	UNSRI	UNTAN	UMA	UDA	UISU
1. Electric Circuit			a)			b)
1.1 Ohm's law	*			*		
1.2 Kirchhoff's law	*			*	*	
1.3 D.C. circuit	*					
1.4 Series circuit		*		*		
1.5 Parallel circuit		*		*		
1.6 R-C-L circuit	*			*		
1.7 Breakdown voltage of R, C and L					*	
1.8 A.C. circuit	*					
1.9 Voltage and current in a R-C-L circuit	*					
1.10 Change of the voltage and current with the frequency change in the R-C-L circuit	*					
1.11 Four terminal network	*			*	*	
1.12 Thevenin and Norton theorem	*	*		*	*	
1.13 Superposition principle				*	*	
1.14 Electric power	*			*	*	
1.15 Improvement of power factor				*	*	
1.16 Phase shift					*	
1.17 Transient phenomena					*	
1.18 Resonance						
1.19 Three phase system	*					
1.20 Mutual induction	*					
1.21 Network				*		
2. Electric Measurement		c)	d)			
2.1 Electric measurement instruments	*			*		
2.2 R-C-L elements	*					
2.3 Circuit meter					*	
2.4 Electronic circuit meter						
2.5 Potentiometer					*	

Table 3-8 (2) Actual Activities in Electrical Engineering Laboratories

Theme	USU	UNSRI	UNTAN	UMA	UDA	UISU
2.6 Wheatstone bridge				*	*	
2.7 Range of ammeter and voltmeter					*	
2.8 Calibration of D.C. ammeters and voltmeters	*					
2.9 Thermocouple					*	
2.10 Measurement of earthing resistance	*			*	*	
2.11 Measureemnt of iron core loss	*				*	
2.12 Wattmeter	*				*	
2.13 Integrating wattmeter				*	*	
2.14 Measurement of 1-phase electric power				*		
2.15 Measurement of 3-phase electric power				*		
2.16 Illuminometer	*					
2.17 Oscilloscope	*					
3. Electric Machines						
3.1 Transformer		*	*	*	*	
3.2 1-phase transformer	*					
3.3 3-phase transformer	*					
3.4 No-load, short-circuit and load tests of 1-phase transformer				*		
3.5 Motor		*	*			
3.6 D.C. motor	*				*	
3.7 Induction motor	*				*	
3.8 Running, stopping, reverse running, load tests of 1-phase induction motor				*		
3.9 Running, stopping, reverse running, load tests of 3-phase induction motor				*		
3.10 Synchronous motor	*					
3.11 Three phase synchronous motor				*		
3.12 Three phase synchronous motor	*			*		
3.13 Cage type synchronous motor		*				
3.14 Shunt synchronous motor		*				

Table 3-8 (3) Actual Activities in Electrical Engineering Laboratories

Theme	USU	UNSRI	UNTAN	UMA	UDA	UISU
3.15 D.C. generator	*					
3.16 No-load, short-circuit and load tests of D.C. generator				*		
3.17 One phase synchronous generator	*				*	
3.18 Three phase synchronous generator				*	*	
3.19 No-load, short-circuit and load and parallel operation tests of 3-phase synchronous generator				*		
3.20 Three phase synchronous generator				*		
3.21 D.C. machines		*	*			
3.22 A.C. machines			*			
3.23 Converter	*			*		
4. High Voltage Technology		e)	f)			
4.1 Measurement of D.C. high voltage	*			*		
4.2 Measurement of A.C. high voltage	*			*		
4.3 Breakdown voltage of gas insulation	*			*		
4.4 Breakdown voltage of oil-immersed transformer	*			*		
4.5 Corona characteristics and corona voltage	*			*		
4.6 Electric field distribution on connected insulators	*			*		
5. Transmission and Distribution						
5.1 Thermal relay	*	g)	h)			
5.2 Measuring relay	*					
5.3 Overcurrent relay	*					
5.4 Inverse time-over current relay	*					
5.5 Directional earth fault relay	*					
5.6 Differential relay	*					
5.7 Detection of cable errors using a cable fault locator	*			*		
5.8 Load simulation				*		
5.9 Load balance in the three phase system				*		
5.10 Electric power system experiment					*	

Table 3-8 (4) Actual Activities in Electrical Engineering Laboratories

Theme	USU	UNSRI	UNTAN	UMA	UDA	UISU
6. Electronics			i)			
6.1 Diode	*			*	*	
6.2 Rectifying circuit	*			*	*	
6.3 Transistor and its application	*			*	*	
6.4 Amplifiers	*			*	*	
6.5 Thyristor	*			*	*	
6.6 TRIAC	*					
6.7 Operational amplifier	*			*		
6.8 Oscillator	*			*	*	
6.9 Multivibrator	*			*	*	
6.10 Thermistor					*	
6.11 Photocell					*	
6.12 Electronics timer	*					
6.13 Electronics circuit		*				
7. Telecommunication						
7.1 Measurement of fidelity	*					
7.2 Measurement of sensitivity	*					
7.3 Measurement of selectivity	*					
7.4 Frequency filter circuit				*		
7.5 Tuning circuit				*		
7.6 Resonance circuit				*		
7.7 Cable impedance characteristics and communication efficiency				*		
7.8 Oscillation circuit				*		
7.9 Modulation and demodulation				*		
7.10 A.M. Transmitter				*		
7.11 Radio		*				
8. Computer and Control System						
8.1 Logic gate and circuit	*					
8.2 Characteristics and operation of AND, OR, NOT, NOR gate circuit				*		
8.3 De Morgan theorem				*		

Table 3-8 (5) Actual Activities in Electrical Engineering Laboratories

Theme	USU	UNSRI	UNTAN	UMA	UDA	UISU
8.4 Sequential circuits (flip-flop)	*					
8.5 Characteristics and operation of flip-flop circuits using IC				*		
8.6 Characteristics of a one bit binary addition and substraction circuits				*		
8.7 Characteristics and operation of comparator circuits	*					
8.8 Characteristics and operation of a BCD decode counter and a BCD to seven segment decoder circuit				*		
8.9 Characteristics and operation of a BCD up and down counter				*		
8.10 Micrprocessor			*			
8.11 Analog computer	*					

Note : a) There are a number of experiments of electric circuits although the details of themes are not available.

b) All experiments are conducted at the University of North Sumatera since there are no facilities of its own. The themes of experiments are the same as those at the North Sumatera University.

c) The details are not available.

d) The details are not available.

e) High voltage technology practices are conducted at Bandung Institute Technology since there are no facilities of its own.

f) High voltage technology practices are conducted at Institute Technology Bandung since there are no facilities of its own.

g) Transmission and Distribution practices are also conducted at Institute Technology Bundung since there are no facilities of its own.

h) Transmission and Distribution practices are also conducted at Institute Technology Bundung since there are no facilities of its own.

i) Basic electronics and power electronics experiments are conducted although the details are not available.

Table 3-9 (1) Details of Model Chemical Laboratory Acitivities

Laboratory Work Category	Laboratory Work Item	Objective and Contents of Study	Major Laboratory Equipment
I. Chemical Analysis	1.1 Qualitative Analysis	Qualitative analysis of inorganic matenyer, cation and anion are carried out using related reagents for qualitative analysis.	Conical Beaker, Magnetic Stirrer, Erlenmeyer Flask. Voll Pippette, Mescylinder, miscellaneous Reagents, Bunzen Burner, Filter Paper, PH Testing Paper, Dessicator, Drying Oven, Platinum Crucible Filtration Funnel, Beaker,
	1.2 Gravimetric Analysis	Metalic element and Inorganic ion will be gravimetricaly analyzed using necessary reagents.	Conicel Beaker, Magnetic Stirrer, Erlenmeyer Flask Voll Pippetle, Mescylinder, Hot plate, Buzen Burner, Washing Bottle, Deminelirizer, Glass Filter, Electric Furnace dessicator, Miscellaneous Chemical Reagents
	1.3 Quantitative Analysis	It includes neutralization titration, oxidation reduction titration and precipitation titration.	Conical Beaker, Beaker, Erlenmeyer Flask, Crystallization shale, Filtration Funnel, Aspirater, Mespippette, Voll pippette, Mes Flask, Magnetic Stirrer, Balance
	1.4 Instrumantal Analysis	Handling and Operation procedure are trained by Instrumental Analyzers such as, refractometer, Fluorescent spectrophotometer, Spectrophotometer and/or Gas Chromatography.	Refractometer, Fluorescent Spectrophotometer, Spectrophotometer,
II Chemical Engineering practice			
1. Measurement of Physical properties	1.1 Measurement of density of liquid	Density of pure liquid and ion mixture of liquid are measured by picre meter in reference to a volume precisely determined by deminelerized water.	Picremeter, Drying Oven, Balance, Constant Temperature Bath, Thermostat
	1.2 Measurement of viscosity of liquid	Viscosity of pure liquid and/or mixture of liquid are measured.	Ostwald Type Viscosimeter, Constant Temperature Bath, Rubber Tuse (soft), Stopwatch, Drying Oven
	1.3 Measurement of vapour pressure	Vapour pressure of liquid are measured.	Aspiraters Ebriometer (300 ml), Thermometer, Mercury manometer, Buffer vessel (pressure type)
	1.4 Correction of Thermometer	Thermometer is corrected using by freezing point methanol Boiling point method.	Thermometer, Erlenmeyer Flask (200 ml), Gas Burner, Tripod, Asbestos Net, Circular Flask, Boilingstone, Jacketed Cylinder, Rubber Stopper etc.
2. Fluid Experiment	2.1 Measurement of flow rate of fluid	Flow rate of fluid is measured by specified orifice flow meter and its measurement are compared with calculated value by a difference pressure before and after the oriffice.	Water Tank, Centrifugal Pump, Head Tank, Orifice type Flow Meter, Manometer, Control Valve, Receiver Tank, Orifice Plate(Miscellaneous size), pipes (size: 1.5 Inch)

Table 3-9 (2) Details of Model Chemical Laboratory Acitivities

Laboratory Work Category	Laboratory Work Item	Objective and Contents of Study	Major Laboratory Equipment
	2.2 Measurement of pressure loss for packed bed	Pressure loss for the packed bed which is packed with glass beads and/or other packing materials and introduced by air, are measured, and Cozeny Constant and shape coeffieiency are caluculated by measured value of physical properties of packed particle.	Packed Tower, Blower, Flow Control Devices, Flow Meter (Float Type), Packing Materials (3 kinds)
3. Heat Transfer Operation	3.1 Heat Convection	Using a double-tube type heat exchanger into which water is introduced and steam is charged out side of pipe, water side heat coefficient is experimentaly measured and related various analysis is carried out.	Jacket Type Heat Exchanger, Thermometer, Valves (Inlet and Outlet for liquid side), Inlet and Outlet valves for steam, Electric Type Boiler (30 kg/HR), Pressure Gauze for steam, Flow meter (Liquid), Mes Cylinder, (1l, 5l) Vent valve, Pump Over-flow vessel.
4. Distillation Operation	4.1 Simple distillation	Volume Change disllate is measured under three components simple distillation operation, and distillation curve is prepared and its data is comparied with theoretical solution and studied.	3way-flask, Thermometer, Riebig Cooler, Mesflask, Mantle Heater, Voltage Controler
	4.2 Fractional Distillaiton Operation	Characteristic perforemance index such as H.T.U and HETP are determined for the fractional distillation operation of two component.	Packed Colum with vacuum Jacket (Top side), still, Cooler(3 pcs), Mantol Heater, Thermometer (5 pcs)
	4.3 Gas Absorption by Packed Column	Absorption of oxygen gas into water is operated by packed column and H.T.U. is determined in the Packed columned.	Reschihig Ring type Packed Column, Oxygen bomb, Orifice type Flow Meter, Over Flow vessel, Thermometer, Pressure Regulator, Do-meter.
	5.1 Measurement of drying velocity of solid	Sands and/or clay balls of uniform size of particle is dryed by hot air and heat transfer coefficient is determined.	Drying Chamber with Balance, Blower, Orifice type Flow meter Preheater, Dry-Wet Thermometer, Temperature Recorder, Balance (Miscellaneous weights), Timer, Stopwatch
	6.1 Adsorption experiment of aromatic compound solution to pulverized activated carbon	Adsorption of p-nitrophenol solution to pulverized activated carbon is carried out and parameters for an isothermal adsorption equation is determined.	Beaker(1 L), Measuring Pippette, Erlenmeyer Flask with stopper (100 ml), Deminelirizer, Flourescenc spectro-photo meter, Vibrator
	6.2 Measurement and Aanlysis of adsorption break through curve for fixed bed	Adsorption break-through curve is determined and analyzed for packed fixed bed with granular activated carbon and overall mass transfer unit NTU is determined.	Over Flow Tank, Adsorption Tower with Jacket Flow Meter, Circulation Pump, Measuring Cylinder Three-way Cock,

Table 3-9 (3) Details of Model Chemical Laboratory Acitivities

Laboratory Work Category	Laboratory Work Item	Objective and Contents of Study	Major Laboratory Equipment
7. Crystallization	7.1 Crystallization operation	Crystallization operation is carried out by continuous complete mixing vessel type crystallizer and production velocity and core generation Velocity are dtermined	Crystallizaiton Vessel with Draft (500 ml, Acrylate Type), Stirrer, Feed Pump, Thermometer, Constant Temperature Bath, Taylor mesh sieve (No 09-200), Aspirator, Drying Oven, Nuche, Filtration Vessel, Filter cloth, Measuring Beaker (10 pcs) Injector, Ammonium Sulfate, Demine liezer,
8. Reaction Kinetics	8.1 Dynamics of stirred Vessel	Using an alanin dye as a tracer, Stirred tank is operated and mixing characteristics and dynamics of the vessel are determined.	Transparent Acrylated mixing vessel with Baffle (5 L, Four blades), Head Tank, Oriffice type Flow meter, Feed Tank, Circulation Pump (Centrifugal) U-type manometer, Spectoro photometer, rotation meter
9. Material Handling	9.1 Measurement of particle distribvution of solid	Distribution pattern of particle is determined as using andoreazen pipette method which is deemed a one sedimentation method.	Andoreazen Pippette, Flyash, Calcium Carbonate powder (sediment action type), Silicasand, Hexamethalic acid soda, Chemical Balance, Weighing pin Desiccator, Meausring Cylinder,
	9.2 Filtration experiment	Coefficient of Filtration, filtration volocity and characteristic of washing are determined by diatomaceous earth	Slurry mixing vessel, Leaf Filter with Filter Cloth (Polypropyrene) Measuring cylinder for Filtrate, Measuring cylinder for washed filtrate Mercury type Mano meter (closed type), Aspirator, Needle valve for pressure control, two-way cock, three-way cock

Table 3-10 Actual Activities in Chemical Engineering Laboratories

Laboratory Work	UNSYIAH	USU	UNSRI	Remarks
1. Chemical Analysis				
1.1 Qualitative Analysis	*	*	*	
1.2 Quantitative Analysis	*	*	*	
1) Titration Analysis	*	*	*	
2) Gravimetric Analysis	*	*	*	
3) Instrumental Analysis	*	*	*	
2. Chemical Engineering Experiment				
2.1 Simple Distillation	-	*	*	
2.2 Heat Convection	*	*	-	
2.3 Spray Drying	-	*	*	
2.4 Mass Transfer Operation in Wetted Wall Column	-	*	-	
2.5 Filtration	*	*	-	
2.6 Fractional Distillation	-	*	-	
2.7 Fluidization	*	-	-	
2.8 Mass Transfer in Fixed Bed	*	-	*	
2.9 Liquid-Liquid Extraction	*	-	*	
2.10 Measurement of Heat Conductivity	-	-	*	
2.11 Gas-Liquid Absorption	-	-	*	
3. Chemical Process Experiment				
3.1 Fermentation of Starch				
3.2				
3.3 Manufacture of Pulp	-	*	-	
3.4 Esterification	*	*	*	
3.5 Synsesis of Urea-Formaldelyde	-	*	-	
4. Micro-Biology				
4.1 Starch Fermentation	-	-	*	
4.2 Micro Organism	-	-	*	

Table 3.11 DETAILS OF MODEL INDUSTRIAL ENGINEERING ACTIVITIES (1/2)

Laboratory Work Category	Laboratory Work Item	Objective and Contents of Study	Major Laboratory Equipment
1. Work Engineering	1.1 Work time Measurement	Determination of Standard work time and consideration of work facilities and equipment in relation to worktime are carried out through time measuremnt for related work item.	Stopwatch, Video recorder, Memo motion apparatus, Micrometer
	1.2 Design of Work System	Work system is designed through a study of the efficiency of the work together with identification of the results of the work time measurement.	8 m/m VTR, Memo-motion apparatus, stopwatch, VTR, Micrometer, Slide screen
	1.3 Work Sampling Analysis	In order to get a quick Judgment of operating condition of workers and/or machine, spot observations of the target work at randam period and overall activities for the work is estimated for whole time of the work.	Tiemswitch, stopwatch, Randam time table, Randam number table, observation sheet, VTR, P/C
2. Factory Layout Planning	2.1 Study of Lay out plan of Factory	Layout plan of a existing factory is studied and a justification of this is analyzed in consideration of manufacturing process and worker's operation area.	Scale facility model, Layout plate, Camera, 8 m/m VTR, Vertical drafter, Drafting tools, Scale Box
	2.2 Design of Layout plan	Layout plan of a specified plant is design through understanding of process, configuration of Equipment and machine, and role of workers.	Educational slide, Drafter, Template, T-square, Scale layout model, Tracing table for perspection Copying machine, Facility scale plate
3. Statistic Engineering	3.1 Analysis of parameters influencing quality of a product	Characteristics of a product is analyzed by miscellanious parameters influencing the product in consideration of the results measured for the product.	P/C, Sampling Tools, 8 m/m VTR
	3.2 Statistical analysis of frequency of presence of alphabetical characters	Per-centage of alphabetical characters at various book in vavious languages is researched and analyzed by linear regression equations.	Random Number Table, P/C, Distribution model, 20-hedron Disc
4. Computer Engineering	4.1 Computer Programming	Operating procedure and utilization of software package are trained and programming is practicaly carried out.	P/C, Software, Autofile
	4.2 Computer Simulation	A Performance characteristics of a system is simulated by formulating a independent parameter to dependent ones keeping the system as black box	P/C

Table 3.11 DETAILS OF MODEL INDUSTRIAL ENGINEERING ACTIVITIES (2/2)

Laboratory Work Category	Laboratory Work Item	Objective and Contents of Study	Major Laboratory Equipment.
5. Mnufacturing Process Technology	5.1 Manufacture of Machine Component	Machine component of machinery parts is manufactured and analyzed of its performance and identification in the production machine	Small size lathe,
6. Environmental Engineering	6.1 Understanding of practical guide line for environmental instruments	Practical criteria for safety problems, working circumstances, hazordas materials and toxic materials is trained. Various environmental analytical instruments such as vibration meters, gas detectors, Lux mete are trained.	8 m/m VTR, Screen Slide, Educational Trans-parency Oxygen meter, Vibration Meter, Hydro carbon Aanlyzer Lux meter, Hazardas gas detector, Fatigue Measurement Apparatus, Variable Lighting device.

Table 3-12 Actual Activities in Industiral Engineering Laboratories

Laboratory Work	USU	UDA	UISU	UMA
1. Work Study				
1.1 Work Measurement	*	*	*	*
1.2 Design of Work System	*	*	*	*
1.3 Work Sampling	*	-	*	*
2. Factory Layout Plan				
2.1 Layout Study	*	*	*	*
2.2 Planning of Layout Plan	*	*	*	*
3. Statistic Analysis				
3.1 Analysis of Parameters relating to quality of product	*	*	*	*
3.2 Statistical Analysis Method	*	-	*	-
4. Computer Engineering				
4.1 Computer Programming	*	*	*	*
4.2 Computer Simulation	*	-	-	-
5. Machine Processing Technique				
5.1 Manufacture of Machine Element	*	-	-	-
6. Environmental Engineering				
6.1 Environment Design	*	-	-	-
6.2 Environmental Analysis Instrument and their Application	*	-	-	-

Table 3-13 (1) Details of Model Mining Enigneering Laboratories

Name of Laboratory	Name of Experiment	Objects and Contents of Experiment	Major Equipment
1. Geology Lab.	1.1 Basic Geology	To study sedimental structure through models	Sediments' Model
	1.2 Basic Rock-Mineral Analysis	To study composition and crystal structure of rocks and minerals	Rock-Mineral Models Sections, Crystal models, Reflex and stereo microscope
	1.3 Geological	To study the way of geological survey through field training or to study the geological structure through Aero-photography	Stereoscope, Clinometer, Geological hammer, Magnifier
2. Mineral Analysis Lab.	Mineral Analysis	To analyse rocks and minerals by means of microscopy method of section samples	Stereo microscope, Reflex microscope, Rock cutter/trimmer, Section sample making equipment, Lapping/polishing machine, X-ray fluorescence analyser, Dryer, Crusher, Abbe refractmeter, Hardness tester, Sieves, Balances
3. Land Survey Lab.	Land Survey	To train leveling and traversing technique	Level, Transit, Tripod, Steel tape, Poles
4. Geophysical Prospecting Lab.	Geophysical Prospecting	In general: To prospect location of structure under ground and geologic structure, geomagnetic character, formation resistivity and secismic character at stratication plan will be measured.	
	4.1 Electrical prospecting	To prospect mineral bed (vein), specific structure underground and other geologic structure, formation resistivity will be measured.	Electrical prospecting system (Resistivity meter, Amplifier, Recorder and others)
	4.2 Electromagnetic Reflection Profiling	To prospect depth, shape of basement and geological structure through electromagnetic reflection profiling method. These geological informations are informed as magnetic value of geological layers.	Electromagnetic reflection profiling system (Proton magnetometer, and others)

Table 3-13 (2) Details of Model Mining Enigneering Laboratories

Name of Laboratory	Name of Experiment	Objects and Contents of Experiment	Major Equipment
	4.3 Seismic Prospecting	P and S-wave transfered through basement and geological layers to be measured to prospect any geological informations under ground.	Seismograph (Seismic Oscillograph Trigger remote controller and etc.) Bed detector
	4.4 Radioactive Well Logging	To prospect depth of oil reservoir, gas reservoir or to constrast geological structures, radioactive ray will be measured.	P-S velocity logging system or Geo logging system
5. Mining Exploitation	Exploitation	In General: To study practical method for exploitation (practical exploitation, intake area detour, grauting at mining road/drive)	
	5.1 Air Compression Testing	As soft ground exploitation in general air pressure inside the tunnel will be increased to aviod cave-in and water excude. An air compression testing (experiment) is an experiment to teach safety exploiting through practical simulation	Compressor, Pressure gauge, Air flow meter, Prony Brake and etc.
	5.2 Rock Drilling	To practice rock drilling by means of a machine drill or an auger	Machine drill, Drill bit, Rod, Jack, Drifter, Auger, Syncroscope, Electromagnetic osillograph, Torsion meter, Amplifier, Boring machine, etc.
	5.3 Mud Logging	To evaluate oil showing by quantitative analysis of oil or gas content in the mud sample	Gas chromatograph, Hydrometer, Viscosimeter, Sulfer analyser, Nitrogen Analyser, Evaporator, pH meter, etc.
	5.4 Ventilation Testing	To study safety design of mining road by measuring air circulation condition	Axial fan, Centrifugal fan, Rotating meter, Watt meter, Ammeter, Airometer

Table 3-13 (3) Details of Model Mining Enigneering Laboratories

Name of Laboratory	Name of Experiment	Objects and Contents of Experiment	Major Equipment
	5.5 Tunnel Safety Design	To practice safety design of coal or ore mining road by studying gas break-out, gas residence, temperature increase and other environmental breaking out mechanism	Transit, Level, Pocket compass, Respirator
6. Mining Mechanics	Mining Mechanics	In General: To practice operation, installation, maintenance method of equipment necessary for mining engineering	
	6.1 Cutting Resistivity Testing	In order to measure a character of stress propagation and breaking character, rock sample or discontinuous layer which has a fault or a joint will be looked into of their uniaxial compression strength.	Electromagnetic oscillograph, Resistivity torque meter, Dinamometer, Shore hardness tester, Shummit hammer, Shear testing machine Maffle Furnece, Table balance, Constant temperature drying chamber, Penetration resistivity testing machine
	6.2 Mining Machine Design	To practice designing for necessary equipment for mining engineering	Drawing table, Drafting machine, Table top calculator
	6.3 Haulage Testing (Off-the-Road Houling)	To practice haulage method of to study cost effective haulage method	Mini conveyor, Shoot, feeder, Small hoist, Scraper, Motor, Hydraulic pump
	6.4 Rope Strength Testing	Testing pull rope and main rope of their strength	Wire fatigue testing machine, Wire rolling testing machine, Wire bending testing machine, Wire torsion testing machine
	6.5 Roof Control and Testing Strut	Measure mine stress to estimate strut or structure's strength	Iron strut, Hinged bar, stress gauge, Resistive torque meter, Recording oscillograph, Photoelasticity testing equiment

Table 3-13 (4) Details of Model Mining Enigneering Laboratories

Name of Laboratory	Name of Experiment	Objects and Contents of Experiment	Major Equipment
7. Mineral Dressing	7.1 Screen Analysis	To make quantitative analysis of mineral or ore samples by means of screening	Standard sieve, Riffle sampler, Sand bath, Infrared dryer, Jaw crusher, Stamp mill, Hammer mill, Sample grinder, Rod mill, Hot mill
	7.2 Separation Test	To analyse content of rare metal within a vein	Mineral jig, Shaking table, Hydro-cyclone separater, Glass type floating separater, Mechanical floating separater, Magnetic separater, Filtering apparatus, Air flow meter, Liquid flow meter, Muffle furnace, P Nano ammeter, etc.
	7.3 Oil Analysis	API, Evaporation pressure, Viscocity, Sulfer content, Nitogen content, Salinity, Water content, Heavy metal content and other necessary data will be examined to determine quality of oil. (Practice)	Centrifuge plarograph, Titlation apparatus, Photoelectric colorimeter, Flame photometer, Salinometer, Water content analyser, Infrared spectrophotometer, Spectrophotometer, Sulfer analyser, Ni-analyser etc.

Table 3-14 Actual Activities in Mining Enginnering Laboratory

Laboratory Work	UNSRI	UDA
1. Basic geology		
1.1 Basic Study	*	*
1.2 Rock/Mineral	*	*
1.3 Obserbation	*	*
1.4 Field Study	*	*
2. Mineral Analysis	*	*
3. Land Surveying	*	*
4. Geophysical Prospecting		
4.1 Electrical prospecting	-	-
4.2 Elctromagnetic reflection Prospecting	-	-
4.3 Seismic Prospecting	-	-
4.4 Radioactive Well Logging	-	-
5. Exploitation		
5.1 Air Compression Testing	-	-
5.2 Rock Drilling	*	*
5.3 Mud Logging	-	-
5.4 Ventilation Testing	*	-
5.5 Tunnel Safety Desingn	*	-
6. Mining Machine		
6.1 Mining Machine Design	-	-
6.2 Haulage Testing	*	-
6.3 Rope Strength Testing	-	-
6.4 Roof Control and Strut Testing	*	-