

**NCEES Principles and Practice of Engineering Examination
MECHANICAL—HVAC AND REFRIGERATION Exam Specifications**

Effective beginning with the April 2017 Examinations

- The exam is an 8-hour open-book exam. It contains 40 multiple-choice questions in the 4-hour morning session, and 40 multiple-choice questions in the 4-hour afternoon session. Examinee works all questions.
- The exam uses U.S. Customary System (USCS) units.
- Sea level conditions apply unless otherwise noted.
- The exam is developed with questions that will require a variety of approaches and methodologies, including design, analysis, and application.
- The knowledge areas specified as examples of kinds of knowledge are not exclusive or exhaustive categories.

	Approximate Number of Questions
I. Principles	32
A. Basic Engineering Practice	4
1. Units and conversions	
2. Economic analysis	
3. Electrical concepts (e.g., power consumption, motor ratings, heat output, amperage)	
B. Thermodynamics	4
1. Cycles	
2. Properties	
3. Compression processes	
C. Psychrometrics (e.g., sea level, 5,000-ft elevation)	8
1. Heating/cooling processes	
2. Humidification/dehumidification processes	
D. Heat Transfer	7
E. Fluid Mechanics	4
F. Energy/Mass Balances	5
II. Applications	48
A. Heating/Cooling Loads	8
B. Equipment and Components	18
1. Cooling towers and fluid coolers	
2. Boilers and furnaces (e.g., efficiencies, fuel types, combustion)	
3. Heat exchangers (e.g., shell and tube, plate and frame)	
4. Condensers/evaporators (e.g., chillers, variable refrigerant flow, heat pumps)	
5. Pumps/compressors/fans (e.g., laws, efficiency, selection)	
6. Cooling/heating coils	

- 7. Control systems components (e.g., valves, dampers)
- 8. Refrigerants (e.g., properties, types)
- 9. Refrigeration components (e.g., expansion valves, accumulators)
- C. Systems and Components 18
 - 1. Air distribution (e.g., air handlers, duct design, system type, terminal devices)
 - 2. Fluid distribution/piping (e.g., hydronic, oil, fuel gas, compressed air, steam, system type)
 - 3. Refrigeration (e.g., food storage, cooling and freezing)
 - 4. Energy recovery (e.g., enthalpy wheels, heat pipes, run-around systems)
 - 5. Basic control concepts (e.g., economizer, temperature reset)
- D. Supportive Knowledge 4
 - 1. Codes and standards
 - 2. Air quality and ventilation (e.g., filtration, dilution)
 - 3. Vibration control (e.g., transmission effect, isolation)
 - 4. Acoustics (e.g., sound control, absorption, attenuators, noise-level criteria)

**Principles and Practice of Engineering Examination
MECHANICAL—MACHINE DESIGN AND MATERIALS Exam Specifications**

Effective Beginning with the April 2017 Examinations

- The exam is an 8-hour open-book exam. It contains 40 multiple-choice questions in the 4-hour morning session, and 40 multiple-choice questions in the 4-hour afternoon session. Examinee works all questions.
- The exam uses both the International System of units (SI) and the U.S. Customary System (USCS).
- The exam is developed with questions that will require a variety of approaches and methodologies, including design, analysis, and application.
- The knowledge areas specified as examples of kinds of knowledge are not exclusive or exhaustive categories.

	Approximate Number of Questions
I. Principles	40
A. Basic Engineering Practice	9
1. Engineering terms, symbols	
2. Interpretation of technical drawings	
3. Quality assurance/quality control (QA/QC)	
4. Project management and economic analysis	
5. Units and conversions	
6. Design methodology (e.g., identifying requirements, risk assessment, verification/validation)	
B. Engineering Science and Mechanics	10
1. Statics	
2. Kinematics	
3. Dynamics	
C. Material Properties	8
1. Physical (e.g., density, melting point, optical)	
2. Chemical (e.g., corrosion, alloys, oxidation)	
3. Mechanical	
a. Time-independent behavior (e.g., modulus, hardness, thermal expansion)	
b. Time-dependent behavior (e.g., creep, viscoelastic, thermal conductivity)	
D. Strength of Materials	10
1. Stress/strain (e.g., tension, compression)	
2. Shear	
3. Bending	
4. Buckling	
5. Torsion	

6. Fatigue	
7. Failure theories (e.g., Von Mises, maximum shear stress)	
E. Vibration	3
1. Natural frequencies (e.g., linear, bending, torsional) and acoustics	
2. Damping (e.g., frequency, damping ratio, critical damping)	
3. Forced vibrations (e.g., magnification factor, transmissibility, balancing, isolation)	
II. Applications	40
A. Mechanical Components	18
1. Pressure vessels and piping (e.g., thick/thin wall)	
2. Bearings (e.g., types, lubrication analysis, life-load analysis)	
3. Gears (e.g., types, speed analysis, force analysis)	
4. Springs (e.g., types, force analysis, fatigue analysis)	
5. Dampers (e.g., types, selection)	
6. Belt, pulley and chain drives (e.g., types, force analysis)	
7. Clutches and brakes (e.g., types, torque/force analysis)	
8. Power screws (e.g., types, lifting and lowering torque, locking conditions)	
9. Shafts and keys (e.g., torsion, bending, static/fatigue failure, stress risers)	
10. Mechanisms (e.g., linkages, cams, slider crank, levers, force analysis, kinetic analysis)	
11. Basic mechatronics (e.g., electromechanical interfaces, sensors, basic circuits, basic controls)	
12. Hydraulic and pneumatic components (e.g., pumps, cylinders, presses)	
13. Motors and engines (e.g., energy conservation, efficiency)	
B. Joints and Fasteners	12
1. Welding and brazing (e.g., types, symbols, stress analysis)	
2. Bolts, screws, rivets (e.g., grade/class selection, preload, fastener group force analysis)	
3. Adhesives (e.g., types, analysis)	
C. Supportive Knowledge	10
1. Manufacturing processes (e.g., machining, molding, heat treatment)	
2. Fits and tolerances	
3. Codes and standards	
4. Computational methods and their limitations (e.g., FEA, CAE)	
5. Testing and instrumentation	

**NCEES Principles and Practice of Engineering Examination
MECHANICAL—THERMAL AND FLUID SYSTEMS Exam Specifications**

Effective Beginning with the April 2017 Examinations

- The exam is an 8-hour open-book exam. It contains 40 multiple-choice questions in the 4-hour morning session, and 40 multiple-choice questions in the 4-hour afternoon session. Examinee works all questions.
- The exam uses both the International System of units (SI) and the U.S. Customary System (USCS).
- The exam is developed with questions that will require a variety of approaches and methodologies, including design, analysis, and application.
- The knowledge areas specified as examples of kinds of knowledge are not exclusive or exhaustive categories.

	Approximate Number of Questions
I. Principles	32
A. Basic Engineering Practice	6
1. Engineering terms, symbols, and technical drawings	
2. Economic analysis	
3. Units and conversions	
B. Fluid Mechanics	6
1. Fluid properties (e.g., density, viscosity)	
2. Compressible flow (e.g., Mach number, nozzles, diffusers)	
3. Incompressible flow (e.g., friction factor, Reynolds number, lift, drag)	
C. Heat Transfer Principles (e.g., convection, conduction, radiation)	6
D. Mass Balance Principles (e.g., evaporation, dehumidification, mixing)	4
E. Thermodynamics	6
1. Thermodynamic properties (e.g., enthalpy, entropy)	
2. Thermodynamic cycles (e.g., Combined, Brayton, Rankine)	
3. Energy balances (e.g., 1st and 2nd laws)	
4. Combustion (e.g., stoichiometrics, efficiency)	
F. Supportive Knowledge	4
1. Pipe system analysis (e.g., pipe stress, pipe supports, hoop stress)	
2. Joints (e.g., welded, bolted, threaded)	
3. Psychrometrics (e.g., dew point, relative humidity)	
4. Codes and standards	

II. Hydraulic and Fluid Applications	24
A. Hydraulic and Fluid Equipment	15
1. Pumps and fans (e.g., cavitation, curves, power, series, parallel)	
2. Compressors (e.g., dynamic head, power, efficiency)	
3. Pressure vessels (e.g., design factors, materials, pressure relief)	
4. Control valves (e.g., flow characteristics, sizing)	
5. Actuators (e.g., hydraulic, pneumatic)	
6. Connections (e.g., fittings, tubing)	
B. Distribution Systems (e.g., pipe flow)	9
III. Energy/Power System Applications	24
A. Energy/Power Equipment	8
1. Turbines (e.g., steam, gas)	
2. Boilers and steam generators (e.g., heat rate, efficiency)	
3. Internal combustion engines (e.g., compression ratio, BMEP)	
4. Heat exchangers (e.g., shell and tube, feedwater heaters)	
5. Cooling towers (e.g., approach, drift, blowdown)	
6. Condensers (e.g., surface area, materials)	
B. Cooling/Heating (e.g., capacity, loads, cycles)	6
C. Energy Recovery (e.g., waste heat, storage)	5
D. Combined Cycles (e.g., components, efficiency)	5

**NCEES Principles and Practice of Engineering Examination
CIVIL BREADTH and WATER RESOURCES and ENVIRONMENTAL DEPTH
Effective Beginning with the April 2015 Examinations**

- The civil exam is a breadth and depth examination. This means that examinees work the breadth (AM) exam and one of the five depth (PM) exams.
- The five areas covered in the civil examination are construction, geotechnical, structural, transportation, and water resources and environmental. The breadth exam contains questions from all five areas of civil engineering. The depth exams focus more closely on a single area of practice in civil engineering.
- Examinees work all questions in the morning session and all questions in the afternoon module they have chosen. Depth results are combined with breadth results for final score.
- The exam is an 8-hour open-book exam. It contains 40 multiple-choice questions in the 4-hour AM session, and 40 multiple-choice questions in the 4-hour PM session.
- The exam uses both the International System of Units (SI) and the US Customary System (USCS).
- The exam is developed with questions that will require a variety of approaches and methodologies, including design, analysis, and application. Some problems may require knowledge of engineering economics.
- The knowledge areas specified as examples of kinds of knowledge are not exclusive or exhaustive categories.
- The specifications for the **AM exam** and the **Water Resources and Environmental PM exam** are included here.

CIVIL BREADTH Exam Specifications

	Approximate Number of Questions
I. Project Planning	4
A. Quantity take-off methods	
B. Cost estimating	
C. Project schedules	
D. Activity identification and sequencing	
II. Means and Methods	3
A. Construction loads	
B. Construction methods	
C. Temporary structures and facilities	
III. Soil Mechanics	6
A. Lateral earth pressure	
B. Soil consolidation	
C. Effective and total stresses	
D. Bearing capacity	
E. Foundation settlement	
F. Slope stability	

IV. Structural Mechanics	6
A. Dead and live loads	
B. Trusses	
C. Bending (e.g., moments and stresses)	
D. Shear (e.g., forces and stresses)	
E. Axial (e.g., forces and stresses)	
F. Combined stresses	
G. Deflection	
H. Beams	
I. Columns	
J. Slabs	
K. Footings	
L. Retaining walls	
V. Hydraulics and Hydrology	7
A. Open-channel flow	
B. Stormwater collection and drainage (e.g., culvert, stormwater inlets, gutter flow, street flow, storm sewer pipes)	
C. Storm characteristics (e.g., storm frequency, rainfall measurement and distribution)	
D. Runoff analysis (e.g., Rational and SCS/NRCS methods, hydrographic application, runoff time of concentration)	
E. Detention/retention ponds	
F. Pressure conduit (e.g., single pipe, force mains, Hazen-Williams, Darcy-Weisbach, major and minor losses)	
G. Energy and/or continuity equation (e.g., Bernoulli)	
VI. Geometrics	3
A. Basic circular curve elements (e.g., middle ordinate, length, chord, radius)	
B. Basic vertical curve elements	
C. Traffic volume (e.g., vehicle mix, flow, and speed)	
VII. Materials	6
A. Soil classification and boring log interpretation	
B. Soil properties (e.g., strength, permeability, compressibility, phase relationships)	
C. Concrete (e.g., nonreinforced, reinforced)	
D. Structural steel	
E. Material test methods and specification conformance	
F. Compaction	
VIII. Site Development	5
A. Excavation and embankment (e.g., cut and fill)	
B. Construction site layout and control	
C. Temporary and permanent soil erosion and sediment control (e.g., construction erosion control and permits, sediment transport, channel/outlet protection)	
D. Impact of construction on adjacent facilities	
E. Safety (e.g., construction, roadside, work zone)	

CIVIL–WATER RESOURCES and ENVIRONMENTAL Depth Exam Specifications

	Approximate Number of Questions
I. Analysis and Design	4
A. Mass balance	
B. Hydraulic loading	
C. Solids loading (e.g., sediment loading, sludge)	
D. Hydraulic flow measurement	
II. Hydraulics–Closed Conduit	5
A. Energy and/or continuity equation (e.g., Bernoulli, momentum equation)	
B. Pressure conduit (e.g., single pipe, force mains, Hazen-Williams, Darcy-Weisbach, major and minor losses)	
C. Pump application and analysis, including wet wells, lift stations, and cavitation	
D. Pipe network analysis (e.g., series, parallel, and loop networks)	
III. Hydraulics–Open Channel	5
A. Open-channel flow	
B. Hydraulic energy dissipation	
C. Stormwater collection and drainage (e.g., culvert, stormwater inlets, gutter flow, street flow, storm sewer pipes)	
D. Sub- and supercritical flow	
IV. Hydrology	7
A. Storm characteristics (e.g., storm frequency, rainfall measurement, and distribution)	
B. Runoff analysis (e.g., Rational and SCS/NRCS methods)	
C. Hydrograph development and applications, including synthetic hydrographs	
D. Rainfall intensity, duration, and frequency	
E. Time of concentration	
F. Rainfall and stream gauging stations	
G. Depletions (e.g., evaporation, detention, percolation, and diversions)	
H. Stormwater management (e.g., detention ponds, retention ponds, infiltration systems, and swales)	
V. Groundwater and Wells	3
A. Aquifers	
B. Groundwater flow	
C. Well analysis–steady state	

VI. Wastewater Collection and Treatment	6
A. Wastewater collection systems (e.g., lift stations, sewer networks, infiltration, inflow, smoke testing, maintenance, and odor control)	
B. Wastewater treatment processes	
C. Wastewater flow rates	
D. Preliminary treatment	
E. Primary treatment	
F. Secondary treatment (e.g., physical, chemical, and biological processes)	
G. Nitrification/denitrification	
H. Phosphorus removal	
I. Solids treatment, handling, and disposal	
J. Digestion	
K. Disinfection	
L. Advanced treatment (e.g., physical, chemical, and biological processes)	
VII. Water Quality	3
A. Stream degradation	
B. Oxygen dynamics	
C. Total maximum daily load (TMDL) (e.g., nutrient contamination, DO, load allocation)	
D. Biological contaminants	
E. Chemical contaminants, including bioaccumulation	
VIII. Drinking Water Distribution and Treatment	6
A. Drinking water distribution systems	
B. Drinking water treatment processes	
C. Demands	
D. Storage	
E. Sedimentation	
F. Taste and odor control	
G. Rapid mixing (e.g., coagulation)	
H. Flocculation	
I. Filtration	
J. Disinfection, including disinfection byproducts	
K. Hardness and softening	
IX. Engineering Economics Analysis	1
A. Economic analysis (e.g., present worth, lifecycle costs, comparison of alternatives)	

**NCEES Principles and Practice of Engineering Examination
FIRE PROTECTION Exam Specifications**

Effective Beginning with the October 2012 Examinations

- The exam is an 8-hour open-book exam. It contains 40 multiple-choice questions in the 4-hour morning session, and 40 multiple-choice questions in the 4-hour afternoon session. Examinee works all questions.
- The exam uses both the International System of units (SI) and the US Customary System (USCS).
- The exam is developed with questions that will require a variety of approaches and methodologies, including design, analysis, and application.
- The knowledge areas specified as examples of kinds of knowledge are not exclusive or exhaustive categories.
- Codes and standards applicable to the exam will be those effective December 31 of the year preceding the exam.

	Approximate Number of Questions
I. Fire Protection Analysis	16
A. Types of Analysis	6
1. Hazard analysis (e.g., flammable liquids, high-piled storage, electrical)	
2. Risk analysis (e.g., likelihood, severity, impact)	
3. Limitations of analyses	
4. Data interpretation	
B. Information Sources for Analysis	10
1. Uncertainty and safety factors	
2. Functional use and operation of facility (e.g., industrial processes, occupancy, facility contents)	
3. Acceptable thresholds (e.g., maximal temperature, heat flux, gas concentration)	
4. Codes and standards	
5. Occupancy, hazard, and commodity classifications	
6. Fire test methods (e.g., classification, product or material characteristics)	
7. Fire test data (e.g., sources, interpretation)	
8. Exposures (e.g., proximal distance from hazards)	
9. Technical drawings, schematics, and plans (e.g., contract documents, shop drawings, riser diagrams)	
II. Fire Protection Management	4
A. Risk management	
B. Inspection, testing, and maintenance procedures and frequencies	
III. Fire Dynamics	10
A. Fire and smoke behavior	
B. Fire growth	
C. Combustion	
D. Plume entrainment (e.g., axisymmetric, balcony spill, window, corner, wall)	
E. Material properties (e.g., heat of combustion, ignitability, thermal, mechanical, flammable and explosive limits)	
F. Material compatibility (e.g., storage arrangements, water reactives)	
G. Heat transfer from fire and smoke	

IV. Active and Passive Systems	40
A. Water-Based Fire Suppression Systems	12
1. Design criteria (e.g., water supply, densities, pressure requirements, design areas, capabilities and limitations)	
2. Hydraulic calculations (e.g., new and existing systems validation, including pipe schedule systems)	
3. System types (e.g., wet and dry pipe, pre-action)	
4. System components (e.g., sprinkler types, valves, flow detection, pipe and fitting material selection, cross-connection control, hanging and bracing)	
5. Placement (e.g., obstructions, ambient conditions)	
6. Water supply and distribution (e.g., public, private, storage tanks)	
7. Fire pumps and controllers	
8. Testing protocol (e.g., hydrostatic, pneumatic, duration, environmental considerations, water supply)	
B. Special Hazard Systems	8
1. Design criteria (e.g., capabilities and limitations of the design)	
2. Design method (e.g., total flooding, local application, or coverage area)	
3. Pipe sizing (calculation input and output)	
4. System types (e.g., low-pressure and high-pressure CO ₂ , chemical and inert clean agents, wet and dry chemical, water mist, foam)	
5. System components (e.g., valves, nozzles, pipe and fitting selection, hanging and bracing)	
6. Agent storage	
7. Personnel safety	
8. Controls (e.g., actuation, pre-alarm, release, detection)	
9. Collateral damage (e.g., toxic or acid byproducts, positive and negative pressure effects, environmental considerations)	
10. System interlocks (e.g., damper, process shutdown)	
11. Test methods (e.g., enclosure integrity test, pipe integrity test)	
C. Fire Detection and Alarm Systems	6
1. Design criteria (e.g., sequence of operation, full versus partial detection, capabilities and limitations of the design)	
2. System types (e.g., addressable, conventional, emergency communication system, combination)	
3. Control equipment	
4. Initiating devices (e.g., type, placement, performance, ambient conditions)	
5. Notification appliances (e.g., type, placement, performance, voice communication, intelligibility)	
6. Circuit classification and wiring methods	
7. Survivability	
8. Power supplies	
9. Building control functions and system interfaces (e.g., elevator recall, HVAC, smoke control, door releases)	
10. Monitoring (e.g., central station, proprietary)	
11. Test methods (e.g., verify sequence of operation)	
D. Smoke Management Systems	4
1. Design criteria (e.g., objectives, equipment survivability, pressure limits, air leakage, door opening force, capabilities and limitations of the design)	
2. System types (e.g., pressurized stairwells, zone smoke control, natural and mechanical venting, exhaust)	
3. System components (e.g., control equipment, fans, dampers, ductwork)	

4.	Fluid mechanics (e.g., vent flows, plugholing, make-up air velocity)	
5.	Smoke movement (e.g., stack effect, wind, buoyancy)	
6.	Initiating mechanisms	
7.	Power supplies	
8.	System interfaces (e.g., fire alarm, HVAC)	
9.	Test methods (e.g., model code requirements, verification of sequence of operation, component performance, safety)	
E.	Explosion Protection and Prevention Systems	2
1.	Design criteria (e.g., protected hazard, maximum pressure, oven ventilation and explosion venting, agent considerations, capabilities and limitations of the design)	
2.	Design method (e.g., suppression, inerting, isolation, venting, containment, damage-limiting construction)	
3.	Prevention methods (e.g., ignition prevention, humidity control, fuel control [dust layers, vapor concentration])	
4.	Personnel safety (e.g., vent discharge, proximity)	
5.	Collateral damage (e.g., adjacent structures or exposures)	
6.	System interlocks (e.g., dampers, process shutdown)	
7.	Test methods (e.g., other system survivability)	
F.	Passive Building Systems	8
1.	Construction types (e.g., combustible, noncombustible, fire resistive, frame)	
2.	Construction materials (e.g., roofing, sheathing, insulation)	
3.	Height and area limits	
4.	Building separation distance	
5.	Interior finish (e.g., flame-spread rating, critical radiant flux)	
6.	Structural fire resistance (e.g., calculation methods, substitution rules)	
7.	Compartmentalization/barrier (e.g., fire, smoke)	
8.	Protection of openings (e.g., penetration seals, joint systems, dampers, doors, vertical openings)	
V.	Egress and Occupant Movement	10
A.	Means of Egress	7
1.	Design criteria	
2.	Exits (e.g., types, remoteness, travel distances, number, capacity)	
3.	Means of egress components (e.g., exit access, exit, exit discharge)	
4.	Component details (e.g., stairwells, corridors, doors, hardware, elevators)	
5.	Occupancy types (e.g., assembly, detention, business)	
6.	Occupant load	
7.	Emergency lighting	
8.	Marking of the means of egress	
B.	Human Behavior	3
1.	Evacuation movement (e.g., timed egress analysis, egress width, travel time, travel distance, flow rate)	
2.	Human performance capabilities	
3.	Human response to fire cues (e.g., alarm, smoke, and heat)	
4.	Occupant pre-movement	
5.	Toxicology of smoke and heat	