



British Horological Institute

Syllabus Information:-

Certificate in the Repair, Restoration and Conservation of Clocks / Watches

Certificate in the Repair of Clocks

Certificate in the Repair of Watches

Syllabus Amendments, September 2008, for examinations May 2009 onwards:-

- Final Grade Part I : Unit 1 :The Theory of Clocks and Watches and their Repair now includes the booklet:-
“The Practical Lubrication of Watches and Clocks”
- Final Grade Part II : Unit 3 :The Theory of Clocks and Watches and their Repair now includes the booklet:-“The Servicing of Clocks and Watches”
- Final Grade Part II : Unit 7 :Practical Clockmaking Techniques
a revised allocation of marks:-

Action of the Escapement	(55%)
Escapement Accuracy / Quality	(27%)
Quality of Workmanship / Finish	(18%)

January 2009

- There will be no further November Examinations, May examinations will continue as in previous years but an arrangement will be made, if necessary, to provide the opportunity for candidates to enter both Unit 4 and Unit 5 (or Unit 9 and Unit 10) in May 2009.
- Certificate in the Repair of Clocks / Certificate in the Repair of Watches; these BHI qualifications which comprise a number of accredited units from The Certificate in the Repair, Restoration and Conservation of Clocks / Watches will be awarded up to and including the results of the May 2010 Examinations. Subsequently candidates will be required to work towards the full qualification - The Certificate in the Repair, Restoration and Conservation of Clocks / Watches.

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Introduction:-

Aims:-

The award, Certificate in the Repair, Restoration and Conservation of Clocks / Watches is designed to fulfil the following aims:-

- To provide national qualifications, with accredited national standards, recognisable to centres, students and employers within the horological industry.
- Preparation for employment:- a skilled clockmaker / watchmaker working on items where interchangeable parts are available as well as antique clocks / watches which require complex repair procedures, the making of complex and / or delicate components and / or extensive conservation / restoration.
- Provide an award recognised by the British Horological Institute for professional membership – Grad BHI, MBHI, FBHI
- Provide, within the award the opportunity to gain a qualification focussing just on the Repair of Clocks or Watches (Certificate in the Repair of Clocks / Certificate in the Repair of Watches, page 5)

Examination design and structure:-

The qualification comprises three mandatory units relevant to both clocks and watches with two alternative pathways specialising in either clocks or watches. Each pathway comprises five mandatory units.

Three mandatory units:-

Unit 1 : Final Grade Part I : Theory of Clocks and Watches and their Repair

Unit 2 : Final Grade Part I : Practical Clock and Watchmaking Techniques

Unit 3 : Final Grade Part II : Theory of Clocks and Watches and their Repair

and either

Clock Pathway

Five mandatory units:-

Unit 4 : Final Grade Part I

The Practical Repair of Clocks

Unit 5 : Final Grade Part II

The Practical Repair of Clocks

Unit 6 : Final Grade Part II

The Theory of Clocks and Clock Restoration and Conservation

Unit 7 : Final Grade Part II

Practical Clockmaking Techniques

Unit 8 : Final Grade Part II

The Practical Restoration / Conservation of Clocks

Watch Pathway

Five mandatory units:-

Unit 9 : Final Grade Part I

The Practical Repair of Watches

Unit 10 : Final Grade Part II

The Practical Repair of Watches

Unit 11 : Final Grade Part II

The Theory of Watches and Watch Restoration and Conservation

Unit 12 : Final Grade Part II

Practical Watchmaking Techniques

Unit 13 : Final Grade Part II

The Practical Restoration / Conservation of Watches

It is anticipated that most students will sit Final Grade Part I units on completion of the first year and Final Grade Part II Units at the end of the second year.

A table showing the structure of the award:-

The award comprises three generic mandatory units relevant to both the clockmaker and the watchmaker and two alternative pathways specialising in “clocks” or “watches”. “External Assessment” refers to assessment by examination where Institute Examiners consider the quality of candidate responses to theory questions, practical test pieces and the actual serving of clocks and watches. “Internal Assessment” is required for the Record of Repairs and the Portfolio and is conducted by a qualified member of the British Horological Institute (MBHI / FBHI) or alternative qualification approved by the Examinations Board.

Generic Mandatory units:-

The Units 1 and 3 provide a broad syllabus containing the theory of the construction and repair of clocks and watches. Unit 2 focuses on the practical skills required to make and modify components for clocks and watches.

Unit	Unit Title	Assessment Approach
Unit 1	Final Grade Part I: Theory of Clocks and Watches and their Repair (basic theory of the construction and repair and adjustment of clocks and watches)	External assessment 2½ hour examination paper
Unit 2	Final Grade Part I: Practical Clock and Watchmaking Techniques (hand and machine techniques for making and modifying clock / watch parts)	External Assessment:- Make a practical test piece according to the design and dimensions and tolerances provided by a drawing. 3 weeks allocated
Unit 3	Final Grade Part II: Theory of Clocks and Watches and their Repair (advanced theory of the construction, repair and adjustment of clocks and watches)	External assessment:- 2½ hour examination paper

A candidate will select either the “Clock” or the “Watch” pathway, each comprising five mandatory units.

Clock Pathway, five Mandatory Units:-

Unit	Unit Title	Assessment Approach
Unit 4	Final Grade Part I: The Practical Repair of Clocks (practical work dismantling, diagnosing and correcting faults, assembling, adjusting and lubricating clocks)	1. Internal Assessment: Record of Repairs 2. External Assessment:- Making recoil escapement pallets, to fit escape wheel (plate escape wheel and studs provided) 8 hours allocated
Unit 5	Final Grade Part II: The Practical Repair of Clocks (practical work:- dismantling, diagnosing and correcting faults, assembling, adjusting and lubricating more complex clocks.)	1. Internal Assessment:- Record of Repairs 2. External Assessment:- Servicing carriage timepiece complete with dial and hands 8 hrs allocated
Unit 6	Final Grade Part II: The Theory of Clocks and Clock Restoration and Conservation (the theory of the construction, repair, adjustment, restoration and conservation of antique clocks)	External assessment:- 2½ hour examination paper
Unit 7	Final Grade Part II: Practical Clockmaking Techniques (hand and machine techniques for making and modifying delicate and complex clock parts)	External Assessment:- Make a dead beat escape wheel, plate and shoulder screw / stud according to drawing provided. Design and make pallets. 3 weeks allocated
Unit 8	Final Grade Part II : The Practical Restoration / Conservation of Clocks 1. the restoration / conservation of five clocks 2. research, appraisal and evaluation of the practical work:- dismantling, diagnosing and correcting faults, assembling, adjusting lubricating and repairing and replacing components and restoration / conservation of antique clocks These clocks may also be included in the Record of Repairs for Unit 5	1. Internal Assessment :- Complete the restoration / conservation of five clocks. Guidelines, each clock requires more than one component to be made by the candidate and an example of a “complex repair technique” 2. External Assessment:- Portfolio containing, for the five restored clocks:- text, sketches and / or photographs giving:- research / an appraisal of the clock / details of specialised conservation / restoration processes.

Watch Pathway, five Mandatory Units:-

Unit	Unit Title	Assessment Approach
Unit 9	Final Grade Part I: The Practical Repair of Watches (practical work dismantling, diagnosing and correcting faults, assembling, adjusting and lubricating complex quartz watches and the larger calibres of basic mechanical watches)	1. Internal Assessment: Record of Repairs 2. External Assessment:- Servicing watches:- quartz; mechanical (gents manual wind) 12 hours allocated
Unit 10	Final Grade Part II: The Practical Repair of Watches (practical work dismantling, diagnosing and correcting faults, assembling, adjusting and lubricating more complex and smaller calibres of mechanical watches including chronographs)	1. Internal Assessment:- Record of Repairs 2. External Assessment:- Servicing watches:- Mechanical: automatic; stopwatch 12 hours allocated
Unit 11	Final Grade Part II: The Theory of Watches and Watch Restoration and Conservation (the theory of the construction, repair, adjustment, restoration and conservation of watches)	External assessment 2½ hour examination paper
Unit 12	Final Grade Part II: Practical Watchmaking Techniques (hand and machine techniques for making and modifying delicate and complex watch parts)	External Assessment:- Make and fit balance staff; make and fit stem and other component/s e.g. keyless cover 3 weeks allocated
Unit 13	Final Grade Part II : The Practical Restoration / Conservation of Watches 1. the restoration / conservation of five watches 2. research, appraisal and evaluation of the practical work:- dismantling, diagnosing and correcting faults, assembling, adjusting lubricating and repairing and replacing components and restoration / conservation of older watches These watches may also be included in the Record of Repairs for Unit 10	1. Internal Assessment:- 2. Complete the restoration / conservation of five watches. Guidelines, each watch requires more than one component to be made by the candidate and an example of a “complex repair technique” 3. External Assessment:- Portfolio containing, for the five restored watches:- text, sketches and / or photographs giving:- research / an appraisal of the watch / details of specialised conservation / restoration processes.

Candidates, who gain the award, **Certificate in the Repair, Restoration and Conservation of Clocks / Watches**, will have to satisfy the British Horological Institute Examinations Board:-

a) In the three generic mandatory units (Units 1, 2, 3)

and, either

b) In the five mandatory units included in the clock pathway (Units 4, 5, 6, 7, 8)

or

c) In the five mandatory units included in the watch pathway (Units 9, 10, 11, 12, 13)

- **Candidates achieving 40% for the three generic mandatory units and the five mandatory units in either the Clock or Watch pathway receive, the Certificate in the Repair, Restoration and Conservation of Clocks / Watches**
- **Candidates achieving an overall mean result of 66% or greater for the three generic mandatory units and the five mandatory units in either the Clock or Watch pathway receive, the Certificate in the Repair, Restoration and Conservation of Clocks / Watches (Pass with Merit)**

Certificates indicate each unit that has been awarded; a student can therefore choose to initially enter just one or two units and then undertake the whole award over a period of time.

Certificate in the Repair of Clocks / Certificate in the Repair of Watches

(Please note: These BHI qualifications which comprise a number of accredited units from the The Certificate in the Repair, Restoration and Conservation of Clocks / Watches will be awarded up to and including the results of the May 2010 Examinations. Subsequently candidates will be required to work towards the full qualification - The Certificate in the Repair, Restoration and Conservation of Clocks / Watches.

A candidate may wish to focus just on the repair of watches, or clocks, rather than include the modifying or making of parts.

The **Certificate in the Repair of Clocks** will be awarded to candidates who gain Units 1,2,4,3,5.

The **Certificate in the Repair of Watches** will be awarded to candidates who gain Units 1,9,3,10.

Pass:- At least 40% in each of the specified units for Clocks or Watches

Pass with Merit:- An overall average of at least 66% in each of the specified units for Clocks or Watches

If a candidate wishes subsequently to extend the Certificate in the Repair of Clocks / Certificate in the Repair of Watches, this can be achieved by undertaking the additional Units.

No time limit is placed on completion of the Certificate in the Repair, Restoration and Conservation of Clocks / Watches.

Information providing an outline of the content, syllabus, learning outcomes, assessment procedure and guided learning hours is provided within the section allocated for each unit.

Accredited Prior Learning:-

1. **Final Grade Part I and II Units: Unit 1, Unit 2, Unit 3, Unit 9, Unit 10 can be accredited to candidates who have been awarded:-**
WOSTEP certificate (two year course, 3,000 hours, “Watch Repairer Program”)
2. **The following Final Grade Part I Units can be accredited to candidates who have been awarded:-**
 - a) Unit 1 : Intermediate Grade of the British Horological Institute (Theory of Technical Horology)
 - b) Unit 2 : Intermediate Grade of the British Horological Institute (Practical Test Piece)
 - c) Unit 4 : Intermediate Grade of the British Horological Institute (Portfolio, clocks)
 - d) Unit 9 : Intermediate Grade of the British Horological Institute (Portfolio, watches)
3. **The following Final Grade Part II Units can be accredited to candidates who have been awarded:-**
 - a) Units 3 and 6 : Final Grade of the British Horological Institute (Theory of Technical Horology, clocks)
 - b) Unit 5 : Final Grade of the British Horological Institute (Portfolio, clocks)
 - c) Unit 7 : Final Grade of the British Horological Institute (Practical Test piece, clocks)
 - d) Units 3 and 11 : Final Grade of the British Horological Institute (Theory of Technical Horology, watches)
 - e) Unit 10 : Final Grade of the British Horological Institute (Portfolio, watches)
 - f) Unit 12 : Final Grade of the British Horological Institute (Practical Test piece, watches)
4. **Final Grade Part I Units:- Unit 1, Unit 2, Unit 4**
Final Grade Part II Units:- Unit 3, Unit 5, Unit 6
can be accredited to candidates who have been awarded:-
Diploma in Clock Restoration and Conservation, by West Dean College, post graduate award validated by Sussex University in conjunction with BADA.

Unit 1 Final Grade, Part I : Theory of Clocks and Watches and their Repair

Outline:-

This mandatory generic unit provides a broad understanding of the theory of the construction and repair of clocks and watches.

It is anticipated that the student has a full knowledge and understanding of:-

1. Certificate in Clock and Watch Servicing, Unit 1, Theory of Watch and Clock Servicing.
2. The Examinations Board booklet: The Practical Lubrication of Watches and Clocks (All students whether following the “clock” or the “watch” pathway should be familiar with the various sections in the booklet)

N.B. The Institute has provided revised “Contents” pages for the Preliminary, Intermediate and Final Grade Distance Learning Courses. These “Contents” pages give detailed references for the material which is to be examined in this Unit. There are slight differences between the topics listed in this syllabus and the sections present in the “Contents” pages - some theoretical topics within the sections “Clocks” and “Watches” are not present in the Distance Learning Course, these will, in time, be included. **The examination paper, during the interim period, will only include questions focusing on those theoretical topics in the sections “Clocks” and “Watches” which are present in the Distance Learning Course together with practical questions relating to “Clocks”, “Watches” and “Workshop Processes”.**

Syllabus:-

Introduction:-

- Time:-
 - 1) Earth as a clock; atomic timekeeping
 - 2) Apparent solar time, mean solar time, local time, standard time, zone time sidereal time
 - 3) Equation of time
 - 4) Date line
 - 5) Radio controlled clocks, Rugby and International time signals
 - 6) GPS

Clocks:-

- Background to pendulum:-
 - 1) Discovery of pendulum properties by Galileo; Christiaan Huygens; first pendulum clock; patent 1657
 - 2) Description of first pendulum clock; action of escapement
 - 3) Circular error; cycloidal cheeks

Unit 1, Syllabus, Clocks, continued:-

- Pivots and bearings :-
 - 1) Types of pivot:- parallel; conical; cone
 - 2) Defects in pivots
 - 3) Pivot holes; broached holes; side shake; end shake
 - 4) Size and strength of pivots; materials
 - 5) Cone pivots; bearings for cone pivots
 - 6) Bushing worn pivot holes

- Horological gearing:-
 - 1) Toothed wheels; angular velocity; gear ratio
 - 2) Distance of centres; depths and depthing
 - 3) Pitch surface; pitch circle; pitch point
 - 4) Epicycloid; hypocycloid; involute; properties of correct tooth curves; uniform lead
 - 5) Circular pitch; diametral pitch; module; relationship between module and diametral pitch
 - 6) Engaging and disengaging friction
 - 7) Lantern pinions; contrate wheels
 - 8) Time of run between winding

- Overview of escapements:-

Function, types of escapement (recoil; frictional rest; detached; verge; cylinder; Swiss lever; detent; pin pallet)

- Lever escapement, ratchet / club toothed:-
 - 1) General description:-names and description of parts
 - 2) Action:- wheel and pallet; fork and roller
 - 3) Safety action:- guard pin; single roller; double roller; horns; draw
 - 4) Supplementary arc
 - 5) Procedure for dismantling, checking the lever escapement and correcting faults, re-assembly and lubrication,
Faults:- e.g. horn shake; guard pin shake; locking; run to banking

- Floating Balance:-
 - 1) General description:- names; description of parts
 - 2) Action:- wheel and pallet; safety action
 - 3) Regulation; checking; replacing a wire

- Balance and spring:-
 - 1) Brief history
 - 2) Balance:- types of balance (plain, compensated)
 - 3) Balance spring:- types of balance springs
 - 4) Compensation:- Harrison's bi-metallic curb; bi-metallic, mono-metallic compensation balance and spring
 - 5) Breguet overcoil
 - 6) Procedure for dismantling, checking the balance assembly and correcting faults, re-assembly and lubrication.
Faults:- e.g. magnetism; flat / central; curb pins; adjustment for rate / beat

Unit 1, Syllabus, Clocks, continued:-

- Timing Machines and their use:-
 - 1) Types of timing machine
 - 2) Principles of operation
 - 3) Fault diagnosis using the timing machine
Faults:- e.g. rate; beat; poise; escapement; train faults
- Mainsprings:-
 - 1) Properties of springs; good and “set” springs; use of mainspring winder to fit springs
 - 2) Mainspring calculations; rules affecting strength of springs in relationship to length width and thickness
- Striking and chiming mechanisms:-
 - 1) Historical background
 - 2) Countwheel and rack striking clocks:- description and action of mechanism; half hour striking
 - 3) “Modern” variations:- striking work; chiming work; self correcting; hammer and gong arrangements; types of fly
- Lubrication:-
 - 1) Properties of oils:- viscosity; temperature range; stability; anti-creep
 - 2) Stribeck diagram; boundary layer lubrication; carrier liquids; surface tension
 - 3) Types of oils
 - 4) Lubrication of clocks:- cleanliness; range of available oils; application
 - 5) Oiling:- train pivots; striking / striking and chiming clocks; platform escapements
- Recoil anchor escapement:-
 - 1) General description, action, supplementary arc, impulse angle, drop, advantages of recoil escapement, tic-tac escapement
 - 2) Escapement data; drawing the escapement
- Identification and correction of **routine** clock faults:-
 - 1) Train:- pivots; pivot holes; replacing teeth to wheels / barrels
 - 2) Mainspring:- forming new eye; selecting suitable mainspring according to barrel dimensions
 - 3) Striking and chiming work:- incorrect “setting up”; hammer lifting pins; fly spring
 - 4) Recoil escapement:- pallets (by repair / replacement); depthing; wheel (by repair / replacement)
 - 5) Platform escapement:-
 - a) Ratchet / club toothed lever escapement
 - procedure for dismantling, re-assembly and lubrication
 - checking for faults:- e.g. horn shake; guard pin shake; locking; run to banking; hairspring, flat / central; curb pins
 - correcting hairspring faults:- flat / central; curb pins
 - adjustment for rate / beat

Watches – general:-

- The exterior of the watch:-
 - 1) Components:- case band; bezel; gaskets; correctors; etc.
 - 2) Health and the environment:- allergies; radioactive emissions
 - 3) Protective qualities of cases:-
 - i) Chemical:- e.g. salt; atmospheric pollutants
 - ii) Physical:- e.g. temperature; shocks; magnetism
 - iii) Water resistance:- e.g. characteristics of water resistant cases; international standards; terminology and interpretation for the user; divers watches; gas escape valves; duration of water resistance
 - 4) The case:- e.g. fixing movement to the case; types of case construction
 - 5) Winding crowns, push pieces and correctors:- e.g. sealed crown; unsealed crown
 - 6) Watch glasses:- e.g. synthetic; mineral; sapphire glasses
 - 7) Gaskets and cement
 - 8) Dials and hands:- e.g. styles of hands; securing dials
 - 9) Case materials:- e.g. legislation; stainless steel; ceramics; titanium; precious metals
 - 10) Bracelets
- Water resistance:- different types of testing methods e.g. immersion type; air pressure method; condensation test

Watches – the analogue display quartz watch

- Component parts:- e.g. printed circuit; coil; stator; rotor
- The motive force:- e.g. types of battery (use and precautions; theoretical life); capacitors; photovoltaic cells; generators driven by oscillating weight (Seiko kinetic watch); end of life indication; power saving
- Use of insulators; benefits of using engineering plastics
- The stepping motor:- description, operation and component parts; bipolar motor; two phase stepping motor; ultrasonic motor
- The quartz oscillator:- piezo electric effect; effect of ageing; effect of temperature; temperature compensation
- Mechanical components of the quartz watch:- motion work; gear train; calendar work; handsetting mechanism

Unit 1, Syllabus, Analogue Display Quartz Watch, continued:-

- Basic electricity and electrical units:- amp; volt; ohm; multiples and sub multiples of basic units
- Tests for quartz watches:- diagnosis of faults by considering consumption, lower working voltage limit, grounding switch, resistance, rate, continuity
- Regulation:- e.g. trimmer; pulse inhibition; EPROM; step switch; pattern cutting system
- Repair procedures:- e.g. cleaning; lubrication; AC (all clear) shorting; de-magnetising; use of non magnetic tools; care in handling delicate electronic components
- Complex quartz watches:- e.g. alarm; stop watch; chronograph; electronic handsetting; complex digital watches (LED & LCD); perpetual calendar

Watches – mechanical:-

- Different types of mechanical watches :- e.g. pocket watch; wrist watch; self winding; perpetual calendar; repeater; chronograph
- Overview of a simple mechanical watch mechanism:- e.g. pillar plate; barrel and train bars; cocks; the watch train; keyless work; barrel assembly; motion work; friction drive to cannon pinion; centre seconds train, jewelled lever escapement, pin lever escapement
- Tribology:-
 - 1) Definition; surfaces; coefficient of friction; wear
 - 2) Cleaning:- cleaning agents; cleaning machines; COSHH; use, storage and disposal of chemicals
 - 3) Lubrication:- general properties and principles; choosing lubricants
 - 4) Stribeck diagram; boundary layer lubrication; carrier liquids; surface tension
 - 5) Pivots:- types of pivots; jewel holes
 - 6) Procedure for checking pivots and pivot holes; correcting faults; replacing jewels.
Faults:- e.g. worn / damaged pivots; damaged jewels
- The power source - barrel, mainspring, clickwork (manual wind watches):-
 - 1) Description, construction, function and names of components i.e. mainspring; methods of hooking; snailed barrel arbor; recoiling click; unbreakable mainsprings
 - 2) Defects in mainsprings Properties of springs; good and “set” springs
 - 3) Mainspring proportions and calculations rules affecting strength of springs in relationship to length, width and thickness

Unit 1, Syllabus, Watches Mechanical, The power source, continued:-

- 4) Mainspring winder
 - 5) Procedure for dismantling, checking the barrel assembly; correcting faults; re-assembly; lubrication. (Faults:- e.g. incorrect end shake; incorrect side shake to barrel bridge)
- Watch Trains:-
 - 1) Gears:- terminology; description; types; geometric arrangement of gears
 - 2) Wheel and pinion assembly
 - 3) Gear arrangements; different train assemblies
 - 4) The hands and motion work
 - 5) Simple train calculations, e.g. duration; “train”; motion work
 - 6) Procedure for dismantling, checking watch trains and correcting faults, re-assembly and lubrication
Faults:- e.g. worn / damaged pivots / jewels; incorrect end shake
 - Pivots and bearings :-
 - 1) Types of pivot:- parallel; conical; cone
 - 2) Defects in pivots
 - 3) Pivot holes; side shake; end shake
 - 4) Shock resistant watches
 - Horological gearing:-
 - 1) Toothed wheels; angular velocity; gear ratio
 - 2) Distance of centres; depths and depthing
 - 3) Pitch surface; pitch circle; pitch point
 - 4) Epicycloid; hypocycloid; involute; properties of correct tooth curves; uniform lead
 - 5) Circular pitch; diametral pitch; module; relationship between module and diametral pitch
 - 6) Engaging and disengaging friction
 - 7) Time of run between winding
 - Winding and hand setting mechanism:-
 - 1) Description, construction, function and names of components, friction drive
 - 2) Procedure for dismantling, checking winding and handsetting mechanisms and correcting faults, re-assembly and lubrication
Faults:- e.g. cannon pinion tightness; damaged components; incorrect spring tension
 - Overview of escapements:-

Function, types of escapement (recoil; frictional rest; detached; verge; cylinder; Swiss lever; detent; pin pallet)
 - Lever escapement, ratchet / club toothed:-
 - 1) General description:-names and description of parts
 - 2) Action:- wheel and pallet; fork and roller
 - 3) Safety action:- guard pin; single roller; double roller; horns; draw
 - 4) Supplementary arc

Unit 1, Syllabus, Watches Mechanical, Lever Escapement, continued:-

- 5) Procedure for dismantling, checking the lever escapement and correcting faults, re-assembly and lubrication,
Faults:- e.g. horn shake; guard pin shake; locking; run to banking
- Balance and spring assembly:-
 - 1) Brief history
 - 2) Balance:- types of balance (plain, compensated)
 - 3) Balance spring:- types of balance springs
 - 4) Compensation:- Harrison's bi-metallic curb; bi-metallic, mono-metallic compensation balance and spring
 - 5) Breguet overcoil
 - 6) Procedure for dismantling, checking the balance assembly and correcting faults, re-assembly and lubrication.
Faults:- e.g. magnetism; flat / central; curb pins; adjustment for rate / beat
- Watch timing using instruments:-
 - 1) Types of timing machine
 - 2) Principles of operation
 - 3) Fault diagnosis using the timing machine
Faults:- e.g. rate; beat; poise; escapement; train faults
- Simple date mechanisms:-
 - 1) Types of mechanism, e.g. directly driven; semi instantaneous; instantaneous
 - 2) Manual adjustment of the date, e.g. corrector; winding stem; safety devices
 - 3) Procedure for dismantling simple date mechanisms, checking and correcting faults, re-assembly and lubrication (Faults:- e.g. damaged components; burrs)

Workshop Processes:-

- Hand and machine processes to modify and produce clock / watch components:-
 - 1) care and use of hand tools for marking out and cutting brass and steel
 - 2) use of centre and watchmakers lathes
 - 3) hardening, tempering and bluing steel
 - 4) finishing techniques:-
 - a) Producing a polished surface on brass flat and turned surfaces
 - b) Producing a polished surface on steel flat and turned surfaces
 - c) Producing grained flat surfaces
 - d) Silvering
- Selection, use and disposal of cleaning fluids for clocks and watches

Learning Outcomes:-

The successful candidate will be able to:-

General Introduction:-

- understand the principles of time determination

Clocks:-

- understand the construction and operation of single train, striking and chiming clocks
- understand the principles of horological gearing.
- understand the properties of mainsprings as a motive force for clocks
- know the principles of operation and construction of the recoil escapement.
- understand the construction and operation of the pendulum.
- design recoil escapement pallets for different applications.
- understand the principle of operation and construction of the lever escapement in clocks.
- understand the principle and operation of the floating balance.
- diagnose and know how to correct routine faults in clock trains, striking and chiming work, the motive force, lever and recoil escapements.
- know the principles of lubrication and select suitable lubricants for various applications in clocks.

Watches:-

- identify different types of watch movements.
- understand the construction and operation of modern manual winding mechanical watches including date display watches.
- know the principles of lubrication and select suitable lubricants for various applications in watches.
- understand in depth the operation and adjustment of the Swiss lever escapement.
- understand the construction and operation of basic and complex quartz analogue watches.

Unit 1, Learning Outcomes, Watches, continued:-

- understand the use of a variety of methods for the testing of water resistance and the measures adopted by manufacturers to exclude water from watch movements.
- diagnose and know how to correct defects in mechanical watches.

Workshop Processes:-

- be able to understand, commensurate with the requirements for Final Grade Part I practical units, the theoretical background of the use, construction and care of hand tools and machines used in horology. (Unit 2, Practical Clock and Watchmaking Techniques; Unit 4, The Practical Repair of Clocks; Unit 9, The Practical Repair of Watches)
- evaluate the use of differing approaches and materials when making and modifying simple clock and watch components
- identify suitable approaches for achieving polished, grained, silvered, lacquered and blued surfaces on horological components.

Assessment procedure:-

This unit is externally assessed; a 2½ hour examination paper, set by the Examinations Board of the British Horological Institute, assesses the candidate's knowledge and understanding of the Theory of Clocks and Watches and their Repair. Candidates are required to answer four questions from Section A and twenty, from the thirty, short questions in section B. BHI Examiners assess the scripts on the basis of the accuracy and the depth of content; two grades of Pass are awarded Pass (40%) and Pass with Merit (66%).

Unit 2 Final Grade, Part I : Practical Clock and Watchmaking Techniques

Outline:-

This mandatory generic unit includes the practical use of tools and machinery to measure, produce and modify, to close tolerances, interacting brass and steel components for clocks and watches.

Syllabus:-

- Health and safety:- personal; fellow workers; visitors
- Mark out:- from a drawing, using rule, scribe, dividers, centre punch; use of master edge
- Use hacksaw, piercing saw and files to produce to required dimensions and tolerances:- straight; flat; curved; square surfaces
- Drill holes using a drilling machine, countersinking, counterboring
- Use a lathe for turning cylindrical, flat and spherical surfaces (watchmaker's and centre lathe):- use of collets and chucks; centres; compound slide with lathe cutting tools; T-rest and graver; sharpen lathe tools and graver; drilling using twist and flat drills; "catching" a centre; turning and burnishing pivots; filing flats
- Make screws:- cutting threads, internal and external (sizes down to 0.5mm); cutting screw slots; hardening and tempering screws; polishing screw threads; bluing
- Produce square holes:- punching; drilling; filing
- Make punches, cutters for counterboring, etc.
- Fasten components:- rivets; screws
- Produce grained and polished finish to flat and turned surfaces on brass and steel
- Form simple bends to brass and steel components
- Heat treat steel and brass:- hardening; tempering; annealing; bluing
- Use of jewellery tool to insert friction jewels

Learning outcomes:-

The successful candidate will be able to:-

- read drawings to measure and mark out interacting components accurately
- make and modify complex steel and brass clock and watch components to within a general tolerance of + or - 0.05mm with required fits and clearances
- use basic hand tools, a centre lathe, a watchmakers lathe
- cut threads, rivet, heat treat and finish to provide polished, grained and blued surfaces.
- produce components to pattern; replace worn damaged or missing watch components

Assessment procedure:-

This unit is externally assessed, the British Horological Institute provides each candidate with a dimensioned working drawing of an horological assembly of interacting components of intermediate clock / watch dimensions; the making of the assembly requires the use of hand and machine tools. A period of three weeks is allocated for the candidate to produce the assembly.

A declaration signed by the candidate and, where appropriate, the college tutor provides confirmation that the piece is the candidate's own work.

BHI Examiners assess the piece by considering the candidate's achievement within four broad areas:-

Accuracy	(35%)
Quality of workmanship	(35%)
Finish	(30%)

Two grades of pass are awarded, Pass (40%) and Pass with Merit (66%).

Unit 3 Final Grade, Part II : Theory of Clocks and Watches and their Repair

Outline:-

This mandatory generic unit extends the candidate's knowledge of clocks / watches present in Unit 1, Final Grade Part I : The Theory of Clocks and Watches and their Repair

It is essential that the student has a full knowledge and understanding of:-

- a) Certificate in Clock and Watch Servicing, Unit 1, Technician Grade : Theory of Watch and Clock Servicing
- b) Unit 1, Final Grade Part I : Theory of Clocks and Watches and their Repair.
- c) The Examinations Board booklet: The Servicing of Clocks and Watches.

N.B. The Institute has provided revised "Contents" pages for the Preliminary, Intermediate and Final Grade Distance Learning Courses. These "Contents" pages give detailed references for the material which is to be examined in this Unit. There are slight differences between the topics listed in this syllabus and the sections present in the "Contents" pages - some theoretical topics within the sections "Clocks" and "Watches" are not present in the Distance Learning Course, these will, in time, be included. **The examination paper, during the interim period, will only include questions focusing on those theoretical topics in the sections "Clocks" and "Watches" which are present in the Distance Learning Course together with practical questions relating to "Clocks", "Watches" and "Workshop Processes".**

Syllabus:-

Clocks:-

- Dead beat escapement:-
 - 1) Historical background:- George Graham; developments by Earnshaw, Vulliamy and Frodsham
 - 2) General description of Graham dead beat escapement:- name, description and function of parts
 - 3) Escapement action
 - 4) Other types of dead beat escapement:- pin wheel escapement; Brocot escapement; half dead beat escapement
 - 5) Escapement data; drawing the escapement
- The theory of gearing in clocks:-
 - 1) Nomenclature
 - 2) Power gearing; horological gearing
 - 3) Involute gearing in theory and practice
 - 4) Cycloidal gearing in theory and practice
 - 5) Lantern pinions
 - 6) Friction

Unit 3, Syllabus, Clocks, The Theory of Gearing in Clocks, continued:-

- 7) Methods of production:- hobbing; topping
 - 8) Types of gearing:- bevel gears; contra wheels; worm and wheel; helical gears; chain transmission; jumper and spring, ratchet and click
 - 9) Calculating missing wheels and pinions
 - 10) Determining module size for replacing wheels
- Cylinder escapement:-
 - 1) Historical background:- Thomas Tompion; George Graham
 - 2) General description:- name, description and function of parts
 - 3) Escapement action
 - Pin pallet escapement:-
 - 1) General description:- names and description of parts; types of “rollers”
 - 2) Action:- wheel and pallet, fork and “roller”
 - 3) Safety action
 - 4) Identifying and correcting faults:-
 - a) procedure for dismantling, re-assembly and lubrication
 - b) checking for faults:- e.g. worn pivots; pallet pins
 - 400 day clock:-
 - 1) General description:- name, description and function of parts
 - 2) Action of 400 day clock
 - 3) Identifying the 400 day clock
 - Striking and chiming mechanisms:-
 - 1) Ting-tang quarter striking
 - 2) Chiming:- gearing; hammer work and gongs; multiple chimes; strike silent; pinning chime barrel
 - 3) English rack chiming mechanism
 - 4) Repeating:- French / English flirt action
 - 5) Roman numeral striking / ship's bell striking
 - Compensated pendulums:-
 - 1) Historical background
 - 2) Coefficient of linear expansion
 - 3) Types of compensated pendulums:- Graham's mercurial pendulum; Harrison's grid iron pendulum; wood rod pendulums; zinc and steel compensation; invar pendulum
 - Turret clocks:-

N.B. This section is included to ensure a general understanding of turret clocks in case the student wishes to seek employment in this field.
Caution should be advised because this is specialist area requiring suitable public liability insurance and an awareness of the legal responsibilities when working on church clocks.

 - 1) Historical notes
 - 2) Construction of turret clock movements, dial works etc

Unit 3, Syllabus, Clocks, Turret Clocks, continued:-

- 3) Maintenance of turret clocks
 - 4) Electrically rewound clocks
 - 5) Interrupted running train clocks
 - 6) Waiting train clock
- Gravity escapement:-
 - 1) Historical background
 - 2) Double three legged gravity escapement
 - a) Description
 - b) Action
 - 3) Single four legged gravity escapement
 - The balance and Spring Assembly :-
 - 1) Variations in rate due to:-
 - a) Poising error
 - b) Escapement error
 - c) Curb pins
 - d) Centrifugal error
 - e) Pinning point
 - f) Centre of gravity
 - g) Temperature
 - h) Amplitude
 - 2) Compensation methods
 - 3) Breguet hairspring; terminal curves
 - 4) Testing:- e.g. testing in positions; temperature; procedure for evaluating rate and duration on completion of a repair
 - Adjustment of balance and spring:-
 - 1) Background
 - 2) Forces acting on the balance:-
 - a) mainspring
 - b) train
 - c) escapement
 - d) balance
 - e) balance spring
 - 3) Checking the movement and action
 - 4) Regulation
 - 5) Breguet spring
 - Identification and correction of complex clock faults:-
 - 1) Train:- repivoting; replacement of wheel teeth / wheels
 - 2) Platform escapement:-
 - a) Jewelled lever escapement:- horn shake; guard pin shake; virtual locking; run to banking; draw; pivots; jewel holes; pallet jewels

Unit 3, Syllabus, Clocks, Identification and correction of complex clock faults, continued:-

- 3) Dead beat escapement; pallets (correction of wear to adjustable type pallets) by repair / replacement); Brocot pallet pins; depthing; wheel (by repair / replacement)
- 4) 400 day clock:- beat; rate; damaged or incorrectly fitted suspension spring; escapement

Watches:-

- Overview of developmental background to the modern mechanical watch
 - 1) Evolution of the watch; mass production; production of a modern movement
 - 2) The power source:- the fusee; maintaining power;
 - 3) Keyless work:- push piece; negative set, rocking bar
- Pin pallet escapement:-
 - 1) General description:- names and description of parts; types of “rollers”
 - 2) Action:- wheel and pallet, fork and “roller”
 - 3) Safety action
 - 4) Identifying and correcting faults:-
 - a) procedure for dismantling, re-assembly and lubrication
 - b) checking for faults:- e.g. worn pivots; pallet pins
- Cylinder escapement:-
 - 1) Historical background:- Thomas Tompion; George Graham
 - 2) General description:- name, description and function of parts
 - 3) Escapement action
- The theory of gearing in watches:-
 - 1) Nomenclature
 - 2) Power gearing; horological gearing
 - 3) Involute gearing in theory and practice
 - 4) Cycloidal gearing in theory and practice
 - 5) Friction
 - 6) Methods of production:- hobbing; topping
 - 7) Types of gearing:- bevel gears; jumper and spring; ratchet and click
- The balance and Spring Assembly :-
 - 1) Variations in rate due to:-
 - a) Poising error
 - b) Escapement error
 - c) Curb pins

Unit 3, Syllabus, Watches, The Balance and spring assembly, continued:-

- d) Centrifugal error
 - e) Pinning point
 - f) Centre of gravity
 - g) Temperature
 - h) Amplitude
- 2) Compensation methods
 - 3) Breguet hairspring; terminal curves
 - 4) Testing:- e.g. testing in positions; temperature; procedure for evaluating rate and duration on completion of a repair
- Adjustment of balance and spring:-
 - 1) Background
 - 2) Forces acting on the balance:-
 - a) mainspring
 - b) train
 - c) escapement
 - d) balance
 - e) balance spring
 - 3) Checking the movement and action
 - 4) Regulation
 - 5) Breguet spring
 - Replacing a balance staff:-
 - 1) Procedure for replacing balance staff:- e.g. removal of roller; balance spring; removal of balance staff; fitting; riveting; poising (static / dynamic)
 - 2) Tools and equipment:- e.g. staking tool; roller removing tool; poising tool
 - Calendar watches:-
 - 1) Simple calendar watch
 - 2) The day and month indicators
 - 3) Phases of the moon
 - Chronograph Mechanisms:-
 - 1) Terminology, types of mechanisms
 - 2) Column wheel system
 - 3) The cam system
 - 4) Other measurements e.g. tachymeter; telemeter dials
 - Self winding watches:-
 - 1) Principles of operation:- limited rotation; full rotation; winding in one direction; winding in both directions
 - 2) Description, construction, function and names of components, lubrication:-
 - a) Reverser system (toothed wheels that gear alternately)
 - b) Reverser system (wheel and pinion coupling)
 - c) Eccentric cam and pawl lever system

Unit 3, Syllabus, Watches, Self winding watches, continued:-

- 3) Suspension of the oscillating weight:-
 - a) Sliding bolt system
 - b) Screw system
 - c) Ball bearing system
 - 4) The barrel and spring for a self winding watch
 - 5) Procedure for dismantling, checking self winding mechanisms and correcting faults, re-assembly and lubrication
Faults:- e.g. incorrect action of bridge; winding train; weight faults
- Watches with striking mechanisms:-
 - 1) Alarm watches:- description; operation

Restoration and Conservation:-

- Overview of principles of conservation and restoration to enable the student to evaluate the need for alternative approaches – repair, restoration and conservation - (Conservation of Clocks and Watches edited by P B Wills) Sections headed:- Records, Principles and objectives, Conservation.

Workshop Processes:-

- Care and use of watchmakers lathe including attachments
- Depthing tool

Learning Outcomes:-

The successful candidate will be able to:-

Clocks:-

- understand the construction and operation of single train, striking, chiming, repeating clocks and 400 day clocks.
- understand the design and application of horological gearing to clocks.
- calculate the number of teeth / leaves in missing wheels / pinions.
- know the principles of operation and construction of the dead beat escapement.
- diagnose and correct faults in the dead beat escapement.
- diagnose and correct complex faults in the lever escapement.

Unit 3, Learning Outcomes, continued:-

- understand the principles of operation and construction of the cylinder escapement.
- diagnose and know how to correct complex faults in clock trains, striking and chiming work.
- understand the application of the depthing tool to check and correct depthing.
- demonstrate an awareness of the construction of turret clocks.
- appreciate the dangers of undertaking work on turret clocks
- know how to check and service a turret clock.
- understand the principle of the gravity escapement and its operation.
- understand the principles of adjustment of the balance and spring to ensure accurate timekeeping.

Watches:-

- appreciate the principle historical development leading to the manufacture of the modern watch.
- understand the design and application of horological gearing to watches.
- understand the application of the depthing tool to check depthing.
- understand the construction and operation of modern self winding watches.
- understand the construction and operation of simple and perpetual calendar watches.
- understand the construction and operation of various types of chronograph mechanisms.
- understand the construction and operation of alarm and minute repeating watches.
- understand the principles of adjustment of the balance and spring to ensure accurate timekeeping.
- diagnose and know how to correct defects in more complex mechanical watches.

Unit 3, Learning Outcomes, continued:-

Conservation and Restoration:-

- show an awareness of the principles of conservation and restoration applied to clocks and watches.
- evaluate, with regard to an item to be repaired, the need for an approach which involves repair / restoration / conservation.

Assessment procedure:-

This unit is externally assessed; a 2½ hour examination paper, set by the Examinations Board of the British Horological Institute, assesses the candidate's knowledge and understanding of the Theory of Clocks and Watches and their Repair. Candidates are required to answer four questions from Section A and twenty, from the thirty, short questions in section B. BHI Examiners assess the scripts on the basis of the accuracy and the depth of content; two grades of Pass are awarded Pass (40%) and Pass with Merit (66%).

Unit 4 Final Grade, Part I : The Practical Repair of Clocks (Clock Pathway)

Outline:-

The practical repair of clocks from the following range, including the correction of routine defects:-

- 1) Clocks with pendulum:-
 - a) Timepieces:- fusee; going barrel; weight driven clocks
 - b) Striking / chiming:- fusee; going barrel; weight driven clocks
- 2) Clocks with platform escapement (lever and pin pallet):-
 - a) Carriage timepieces
 - b) Mantel clocks
- 3) Clocks with floating balance:-
 - a) Mantel clocks with / without striking

Syllabus:-

- Clock identification:- identify by type and style
- Customer care:- record customer details; give accurate estimates for repairs; record accurate details of clocks and work completed
- Cleaning fluids:- select, use safely and dispose of with respect to the environment
- Dismantle, clean, reassemble lubricate and adjust clocks in the above range
- Identify and correct the following routine defects in clocks from the range outlined above:-
 - 1) Train, going and striking:-
 - a) worn / damaged pivots
 - b) worn pivot holes
 - 2) Motive force:-
 - a) broken mainspring (by repair and replacement)
 - b) broken / damaged click work
 - c) worn / damaged gut and wire lines, fusee chain
 - d) worn barrel arbor pivots and barrel bearings

Unit 4, Syllabus, continued:-

3) Escapement:-

a) Recoil escapement

- errors of beat and rate
- incorrect depthing
- worn / damaged escape wheel teeth (by repair)
- worn / damaged pallets (by refacing)
- worn / damaged pallets (by replacement, including design)

b) Platform escapement, lever and pin pallet

- dirt and congealed oil - requiring cleaning and lubrication
- damaged pivots / jewels; damaged hairspring; incorrect action / safety action (identify only)
- hairspring faults
- errors in beat and rate

c) Floating balance

- dirt and congealed oil – requiring cleaning and lubrication
- damaged suspension wire; damaged suspension spring; incorrect impulse / safety action
- errors in beat and rate

4) Striking Train and Mechanism:-

a) incorrect “setting up”

b) wear / damage to train and motive force

c) minor wear/damage e.g. flyspring; rack tail; lifting and warning levers; hammer spring

5) Pendulum:-

a) damaged suspension springs (by replacement including the modification of pendulum suspensions)

b) damaged pallet arbor pivots

c) worn pivot holes in back cock

d) worn / damaged rating nut / thread

6) Dial and hands:-

a) worn / damaged silvered dials including resilvering and lacquering

b) worn / damaged hands including silver soldering and bluing

c) incorrect alignment of hands

- Use hand and machine tools to mark out, produce / modify and finish delicate interacting clock parts in brass and steel:-
 - 1) hand tools:- files; saws
 - 2) machine tools:- drilling machine; lathe; milling machine,
 - 3) heat treatment:- hardening; tempering; bluing
 - 4) finishing brass and steel:- polished; grained

Learning Outcomes:-

The successful candidate will be able to:-

- dismantle, clean, reassemble, lubricate and adjust clocks from the range applicable to this unit
- diagnose and correct, within the scope provided in the syllabus, routine defects in the range of clocks outlined in this unit.

Assessment Procedure:-

There are two aspects to the assessment of this unit:-

1. Internal assessment:- the candidate prepares a “Record of Repairs” detailing the work completed when repairing eight clocks.
2. External assessment:- the candidate is required to:-
 - a) design and make pallets for a recoil anchor escapement.
 - b) submit a drawing to an enlarged scale showing the geometrical construction of an anchor recoil escapement. Drawings may be produced manually or by CAD and are to comply with BS 308 (as detailed in PP7308).

1. Internal Assessment : Record of Repairs:-

Candidates are required to produce a “Record of Repairs” describing the repair of eight clocks completed within a two year period immediately prior to examination entry.

Each item repaired by a candidate must be documented and then checked by a qualified member of the Institute (MBHI / FBHI).

Forms, which are available from Upton Hall, must be used for documentation:-

- **“List of Contents”**, Final Grade Part I : Unit 4, summarises the work completed and acts as an aide memoire ensuring the candidate completes the necessary number of repairs and the fundamental repair processes. The “List of Contents” gives:-
 - a. The number of repairs required together with advice concerning the type of clocks
 - b. The specific “repair processes” required
- **For each item that has been repaired** a separate form, the **“Clock Form”**, must be used to record a description of the item, faults noted, repair work undertaken etc..

If any repair process does not occur when repairing the clocks the candidate must undertake the process as an exercise, document the exercise on a “Clock Form” and, after ensuring that the assessor has checked the process, include the form with the Record of Record of Repairs. The Assessor Guidance Notes are included, together with further details about the Record of Repairs, in the “Examination Handbook for the Distance Learning Course”, to be found at the front of your copy of the course, and also in “Specimen Papers:- Certificate in the Repair, Restoration and Conservation of Clocks / Watches”. Copies of the forms are provided by the Institute and may be photocopied as required.

2. External Verification / Assessment:-

Verification of the Record of Repairs:-

Each clock has already been internally assessed by qualified professional member of the British Horological Institute (MBHI / FBHI or equivalent approved by the Examinations Board.) The “Record of Repairs” is checked by the BHI Senior Examiner to ensure that the required number of items has been repaired, every item has been approved to indicate that the work was undertaken to a high standard and the nature of the work complies with the guidelines. A Pass is awarded if the “Record of Repairs” is “complete”. The unit is thus competence based and a mark is not awarded.

Assessment of the Recoil Escapement Pallets and Escapement Drawing:-

a) Making recoil escapement pallets:-

The candidate is required to design and make pallets for a recoil anchor escapement. The escape wheel, plate and studs are provided and the candidate designs suitable pallets and proceeds to make and harden the pallets. A Design Data Sheet giving an example of recoil escapement construction is provided for candidates to refer to during the examination; no other reference material is to be used. Eight hours are allocated to complete the exercise. The candidate’s drawing and working escapement are submitted for assessment.

BHI Examiners assess the escapement model on the basis of the quality of the candidate’s work:-

- | | | |
|-------------------------|----------|-------|
| i) accuracy / action | 30 marks | (60%) |
| i) workmanship / finish | 20 marks | (40%) |

b) A drawing, to an enlarged scale, showing the geometrical construction of a Recoil Anchor Escapement:-

BHI Examiners assess the drawing by considering the use of conventions and the correctness of the construction.

It is necessary for the candidate to submit a Record of Repairs that fulfils the requirements of the syllabus.

Providing the candidate gains a Pass for the Record of Repairs, the overall result, a Pass (40%) or a Pass with Merit (66%), is determined from:-

- the making of the recoil anchor escapement pallets (contributing max. 85%)**
- the escapement drawing (contributing max. 15%)**
- a pass (40%) must be gained for both the making of the pallets as well as the escapement drawing:-**
 - making escapement pallets, i.e. a minimum of 34 marks out of the possible maximum of 85 marks**
 - escapement drawing, i.e. a minimum of 6 marks out of the possible maximum of 15 marks**

Summary of the requirements for Unit 4, Final Grade Part I : The Practical Repair of Clocks – Internal assessment (Record of Repairs) and External Assessment:-

Number of repairs required / guidance regarding type of repair, etc.	Repair Processes
<p>Internal Assessment:- A total of eight clock repairs involving, in each instance, a full service not just a “part job”.</p> <p>These should be from the range:-</p> <ol style="list-style-type: none"> 1. Clocks with pendulum:- <ol style="list-style-type: none"> a) Timepiece b) Striking 2. Clocks with platform escapement <ol style="list-style-type: none"> a) Carriage timepiece b) “drum” movement 3. Clocks with floating balance <ol style="list-style-type: none"> a) Mantel clock with / without striking <p>External assessment:- (In addition to Record of Repairs for Unit 4, Final Grade I : The Practical Repair of Clocks)</p> <ol style="list-style-type: none"> 1. The candidate is required to design and make pallets for a recoil anchor escapement. The escape wheel, plate and studs are provided and the candidate designs suitable pallets and proceeds to make and harden the pallets. The candidate’s working drawing and escapement are submitted for assessment. (8 hours allocated) 2. The candidate is to submit with the Record of Repairs an enlarged dimensioned drawing showing a crossed out recoil escape wheel and the construction of the pallets. Drawings, produced manually or by CAD are to comply with BS 308 (as detailed in PP7308), and should include the escapement data. BHI Examiners assess the drawing. 	<p>The following repair processes must be included in the repairs or as exercises:-</p> <ol style="list-style-type: none"> 1. Replace at least two types of pendulum suspension where modification is required. 2. Refinish pivots and replace bushes in complex situations. (e.g. pallet arbor pivots; delicate pivots; barrel bushes; non routine bushing such as back cock) 3. Correct anchor escapement defects:- <ol style="list-style-type: none"> a) reface pallets (requires addition of material and the adjustment to give correct escapement action with the escape wheel) b) adjust depthing c) top / correct damaged wheel teeth 4. Check for faults in lever escapement platform:- <ol style="list-style-type: none"> a) Horn shake:- <ul style="list-style-type: none"> • Equal both sides • Less than total lock • Greater than run to the banking b) Guard pin shake:- <ul style="list-style-type: none"> • Equal both sides • Less than or equal to horn shake c) Locking:- <ul style="list-style-type: none"> • Virtual or drop lock = $1\frac{1}{2}^\circ$ or $\frac{1}{4}$ to $\frac{1}{5}$ of pallet impulse plane d) Run to banking and draw:- <ul style="list-style-type: none"> • $\frac{1}{2}^\circ$ • less than horn shake • draw causes lever to move to banking pin e) Balance spring:- <ul style="list-style-type: none"> • Flatness at collet & cock • Centring at collet & cock • Curb pins • Beat • Rate • Minor distortion 5. Correct balance spring faults 6. Silver and lacquer a dial 7. Blue hands

Unit 5 Final Grade, Part II : The Practical Repair of Clocks (Clock Pathway)

Outline:-

The practical repair of clocks from the following range, including the correction of routine and non routine defects:-

- 1) Clocks with pendulum:-
 - a) Timepieces, including French: fusee; going barrel; weight driven clocks
 - b) Striking, including French: fusee; going barrel; weight driven clocks
 - c) Chiming: fusee; going barrel; weight driven clocks
 - d) Ting tang
 - e) English rack chiming clocks
 - f) Repeating clocks

- 2) Clocks with platform escapement (lever, pin pallet, cylinder):-
 - a) Carriage timepieces
 - b) Carriage strike
 - c) Carriage repeating
 - d) Mantel clocks

- 3) Anniversary Clocks

Syllabus:-

- Clock identification:- identify by type and style

- Customer care:- record customer details; give accurate estimates for repairs; record accurate details of clocks and work completed

- Cleaning fluids:- select, use safely and dispose of with respect to the environment

- Dismantle, clean, reassemble lubricate and adjust clocks in the above range

- Identify and correct / repair, with a sensitivity to established conservation / restoration principles, routine defects and the following non routine defects in clocks from the range outlined above:-
 - 1) Train, going and striking:-
 - a) worn pivots requiring replacement
 - b) broken pivots
 - c) incorrectly depthed wheels and pinions
 - d) damaged wheel / wheel teeth requiring repair / replacement

Unit 5, Syllabus, continued:-

2) Motive force:-

- a) worn / damaged barrel teeth requiring repair
- b) worn / damaged spring hooking (barrel end of spring)
- c) worn damaged barrel / arbor hooking
- d) select suitable replacement spring according to barrel dimensions and existing spring

3) Escapement:-

a) Recoil escapement

- worn / damaged escape wheel by replacement

b) Dead beat escapement (pendulum clock):-

- errors of beat and rate
- worn / damaged “adjustable” pallets
- worn / damaged escape wheel teeth requiring repair

c) Dead beat escapement and suspension, anniversary clock:-

- errors of beat and rate
- action of fork on suspension spring
- damaged suspension spring
- depthing
- pallet adjustment

d) Platform escapement, lever and pin pallet:-

- checking and correcting horn shake:-
 - (i) equal both sides
 - (ii) less than total lock
 - (iii) greater than run to banking
- checking and correcting guard pin shake:-
 - (i) equal both sides
 - (ii) less than or equal to horn shake
- checking and correcting “virtual” or “drop” lock
 - (i) $1\frac{1}{2}^\circ$ or $\frac{1}{4}$ to $\frac{1}{5}$ of pallet impulse plane
- checking and correcting run to the banking and draw:-
 - (i) $\frac{1}{2}^\circ$
 - (ii) less than horn shake
 - (iii) draw causes lever to move to banking pin

b) Platform escapement, cylinder:-

- errors of beat and rate

Unit 5, Syllabus - Escapements, continued:-

c) Identify and correct balance spring faults:-

- flatness:-
 - (i) at the collet
 - (ii) at the cock
- centring:-
 - (i) at the collet
 - (ii) at the cock
- curb pins
- beat
- rate
- minor distortion

d) Striking and chiming mechanisms:-

- wear / damage of complex components, e.g. gathering pallet, pin wheel

Learning Outcomes:-

The successful candidate will be able to:-

- dismantle, clean, reassemble, lubricate and adjust clocks from the range applicable to this unit.
- diagnose and correct, with a sensitivity to conservation / restoration principles, routine and non-routine defects in the range of clocks outlined above.

Assessment Procedure:-

There are two aspects to the assessment of this unit:-

1. Internal assessment:- the candidate prepares a “Record of Repairs” detailing the work completed when repairing ten clocks.
2. External assessment:- the candidate is required to:-
 - a) repair a carriage clock movement (or other timepiece) with introduced faults complete with dial and hands.
 - b) submit a drawing to an enlarged scale showing the geometrical construction of a Graham dead beat escapement. Drawings may be produced manually or by CAD and are to comply with BS 308 (as detailed in PP7308).

Unit 5, Assessment Procedure, continued:-

1. Internal Assessment : Record of Repairs:-

Candidates are required to produce a “Record of Repairs” describing the repair of ten clocks completed within a two year period immediately prior to examination entry. Each item repaired by a candidate must be documented and then checked by a qualified member of the Institute (MBHI / FBHI).

Forms, which are available from Upton Hall, must be used for documentation:-

- **“List of Contents”**, Final Grade Part II : Unit 5, summarises the work completed and acts as an aide memoire ensuring the candidate completes the necessary number of repairs and the fundamental repair processes. The “List of Contents” gives:-
 - a. The number of repairs required together with advice concerning the type of clocks
 - b. The specific “repair processes” required
- **For each item that has been repaired** a separate form, the **“Clock Form”**, must be used to record a description of the item, faults noted, repair work undertaken etc..

If any repair process does not occur when repairing the clocks the candidate must undertake the process as an exercise, document the exercise on a “Clock Form” and, after ensuring that the assessor has checked the process, enclose it with the Record of Repairs. The Assessor Guidance Notes are included, together with further details about the Record of Repairs, in the “Examination Handbook for the Distance Learning Course”, to be found at the front of your copy of the course, and also in “Specimen Papers:- Certificate in the Repair, Restoration and Conservation of Clocks / Watches”. Copies of the forms are provided by the Institute and may be photocopied as required.

2. External Verification / Assessment:-

Verification of the Record of Repairs:-

Each clock has already been internally assessed by qualified professional member of the British Horological Institute (MBHI / FBHI or equivalent approved by the Examinations Board.) The “Record of Repairs” is checked by the BHI Senior Examiner to ensure that the required number of items has been repaired, every item has been approved to indicate that the work was undertaken to a high standard and the nature of the work complies with the guidelines. A Pass is awarded if the “Record of Repairs” is “complete”. The unit is thus competence based and a mark is not awarded.

Assessment of the Carriage Clock Repair and Escapement Drawing:-

- a) Repairing a timepiece carriage clock (or other timepiece) movement:-

Eight hours are allocated for the candidate to repair a carriage clock timepiece movement with introduced faults, complete with dial and hands. The candidate is required to diagnose and correct the faults and service the clock thus involving, dismantling, checking the components, re-assembly, lubrication and adjustment with the use of test equipment.

BHI Examiners assess the repaired movement on the basis of the candidate’s identification and correction of the faults and the quality of the servicing activity.

- b) A drawing, to an enlarged scale showing the geometrical construction of a Graham

dead beat escapement:-

BHI Examiners assess the drawing by considering the use of conventions and the correctness of the construction.

It is necessary for the candidate to submit a Record of Repairs that fulfils the requirements of the syllabus.

Providing the candidate gains a Pass for the Record of Repairs, the overall result, a Pass (40%) or a Pass with Merit (66%), is determined from:-

- a) the servicing of the carriage clock movement (contributing max. 85%)**
- b) the escapement drawing (contributing max. 15%)**
- c) a pass (40%) must be gained for both the servicing of the carriage clock as well as the escapement drawing:-**
 - i) servicing carriage clock movement, i.e. a minimum of 34 marks out of the possible maximum of 85 marks**
 - ii) escapement drawing, i.e. a minimum of 6 marks out of the possible maximum of 15 marks**

Unit 5, continued:-

Summary of the requirements for Unit 5, Final Grade Part II : The Practical Repair of Clocks – Internal assessment (Record of Repairs) and External Assessment:-

Number of repairs required / guidance regarding type of repair, etc.	Repair Processes
<p>Internal Assessment:- A total of ten clock repairs involving, in each instance, a full service not just a “part job”.</p> <p>These should be from the range:-</p> <ol style="list-style-type: none"> 1. Clocks with pendulum, fusee, going barrel and weight driven:- <ol style="list-style-type: none"> a) Timepieces (including French) b) Striking (including French) c) Chiming 2. Clocks with platform escapement:- <ol style="list-style-type: none"> a) Carriage timepiece b) Carriage strike c) Carriage repeating d) Mantel clocks 3. Anniversary clocks <p>External assessment:- (In addition to Record of Repairs for Unit 5, Final Grade II : The Practical Repair of Clocks)</p> <ol style="list-style-type: none"> 1. Repair and service a timepiece carriage clock movement including dial and hands, with introduced faults (time allocated : 8 hours) 2. The candidate is to submit, with the Record of Repairs, an enlarged dimensioned drawing showing a crossed out dead beat escape wheel and the construction of the pallets. Drawings, produced manually or by CAD are to comply with BS 308 (as detailed in PP7308), and should include the escapement data. BHI Examiners assess the drawing. 	<p>The following repair processes must be included in the repairs or as exercises:-</p> <ol style="list-style-type: none"> 1. Replace teeth to wheel and barrel with great wheel 2. Simple repivoting 3. Fit a wheel to a collet / pinion by riveting 4. Check and redepth wheel and pinion 5. Correct faults in lever escapement platform:- <ol style="list-style-type: none"> a) Adjust banking pins to ensure correct horn shake:- <ul style="list-style-type: none"> • Equal both sides • Less than total lock • Greater than run to the banking b) Adjust guard pin to ensure correct guard pin shake:- <ul style="list-style-type: none"> • Equal both sides • Less than or equal to horn shake c) Adjust pallet jewels to ensure correct locking:- <ul style="list-style-type: none"> • Virtual or drop lock = $1\frac{1}{2}^\circ$ or $\frac{1}{4}$ to $\frac{1}{5}$ of pallet impulse plane d) Adjust pallet jewels to ensure correct run to banking and draw:- <ul style="list-style-type: none"> • $\frac{1}{2}^\circ$ • less than horn shake • draw causes lever to move to banking pin

Unit 6 Final Grade, Part II : The Theory of Clocks and Clock Restoration and Conservation (Clock Pathway)

Outline:-

This unit provides extensive background knowledge of many of the mechanisms to be found in antique clocks and details of clocks beyond the range considered in Units 1 and 3. The unit thus provides the underpinning knowledge for Unit 8, Final Grade Part II : The Practical Restoration / Conservation of Clocks.

It is essential that the candidate has completed:-

Unit 1, Final Grade Part I : The Theory of Clocks and Watches and their Repair

and has completed **or** is preparing for:-

Unit 3, Final Grade Part II : The Theory of Clocks and Watches and their Repair

N.B. The Institute has provided revised “Contents” pages for the Preliminary, Intermediate and Final Grade Distance Learning Courses. These “Contents” pages give detailed references for the material which is to be examined in this Unit. There are slight differences between the topics listed in this syllabus and the sections present in the “Contents” pages - some theoretical topics within the sections “Clocks” and “Watches” are not present in the Distance Learning Course, these will, in time, be included. **The examination paper, during the interim period, will only include questions focusing on those theoretical topics in the sections “Clocks” and “Watches” which are present in the Distance Learning Course together with practical questions relating to “Clocks”, “Watches” and “Workshop Processes”.**

Syllabus:-

Time Determination:-

- Background:-
 - 1) Fundamental units
 - 2) Mean solar and sidereal time
 - 3) The earth as a clock
 - 4) Longitude and time zone
 - 5) Determination of clock error
 - 6) IERS

Unit 6, Syllabus, continued:-

Clocks:-

- Historical styles of clocks and movements; researching maker
- The Atmos clock:-
 - 1) General description
 - 2) Principle of the winding mechanism
 - 3) Escapement
 - 4) Action of winding mechanism
- The power source:-
 - 1) Reason for maintaining power
 - 2) Huygen's; Harrison's (fusee and weight driven); bolt and shutter
 - 3) Epicyclic gearing - sun and planet maintaining power
 - 4) Geneva stopwork
 - 5) Stackfreed
 - 6) Adjusting the fusee
 - 7) Tapered mainsprings
- Conical pendulum
- Sidereal pendulum
- Calendar clocks; moonwork; equation of time
- Principles of conservation and restoration:- (Conservation of Clocks and Watches edited by P B Wills)
 - 1) Ethics for the repair and restoration process
 - 2) Records and documentation
 - 3) Principles and objectives
 - 4) Cleaning and lubrication
 - 5) Conservation
 - 6) Restoring Brass dials
- Marine chronometer:-
 - 1) Historical background
 - 2) General description
 - 3) Names and functions of parts
 - 4) Action
 - 5) Examining the escapement:-
 - a) The candidate must understand the need to exercise extreme caution because of the delicate detent which will be damaged if the balance is removed without letting down the mainspring or "blocking" the train
 - b) Adjustments

Unit 6, Syllabus, continued:-

- Balance and Spring:-
 - 1) How a balance spring is produced
 - 2) Properties of the spring – Hooke's Law
 - 3) Limit of elasticity; moment of elasticity; Young's Modulus of Elasticity
 - 4) Compensation
 - 5) Production of a bimetallic balance

- Lever escapement:-
 - 1) History:- rack lever; Thomas Mudge; crank roller; ratchet tooth; George Savage; club tooth escapement

- Electricity and Magnetism
 - 1) Force; charge; electric field
 - 2) Conductors and insulators
 - 3) Batteries; voltage; current and power
 - 4) Resistance and Ohm's Law
 - 5) Circuits; symbols; multiples and sub-multiples
 - 6) Magnetic force; magnetic effects of currents; magnetic induction
 - 7) Capacitance
 - 8) Electric clocks:-
 - a) Switch configurations and switch problems
 - b) Occasional impulsing
 - c) Methods of impulsing
 - d) Electrically rewound mechanical clocks
 - e) Synchronous clocks
 - f) ATO transistor maintained clock
 - g) Failure of electric clocks

- Verge escapement:-
 - 1) General description
 - 2) Action of escapement
 - 3) Repair and restoration

Workshop processes:-

- Hand and machine processes to produce delicate interacting clock components:-
 - 1) care and use of and tools for marking out and cutting brass and steel
 - 2) care and use of centre and watchmakers lathes including attachments
 - 3) care and use of the turns, runners and attachments
 - 4) hardening and tempering steel
 - 5) finishing techniques:-
 - a) Producing spotted finishes on brass
 - b) Producing frosted finishes on brass and steel

Unit 6, Syllabus, Workshop Processes, continued:-

- Materials used in clock making:-
 - 1) Properties of materials
 - 2) Ferrous metals:-
 - a) Iron
 - b) Steel, stainless steel
 - c) Invar; elinvar
 - d) Brass:-
 - i Properties
 - ii Types of brass
 - iii Nickel Brass
 - e) Bronzes; copper; zinc; tin; copper beryllium alloys; aluminium
 - f) Precious and semi-precious materials
 - g) Hard precious or semi-precious stones
 - h) Solder
 - i) Shellac
- Flat drills:-
 - 1) Cutting angles for flat drills
 - 2) Making flat drills for brass, steel and hardened steel
- Techniques for turning a balance staff:-
 - 1) Turning in a collet – one stage
 - 2) Turning in a collet – two stages
 - 3) Turning in two stages – collet and wax chuck
- Techniques for cutting wheels and pinions:-
 - 1) Using a lathe and dividing head
 - 2) Using a wheel cutting engine
 - 3) Calculations for using “commercial” form relieved cutters
 - 4) Producing “fly cutters”
- Striking mechanisms:-
 - 1) Construction of rack and snail

Learning Outcomes:-

The successful candidate will be able to:-

- show an appreciation of the conflicting demands when repairing / conserving / restoring clocks.
- understand the principles of construction and action of the Atmos clock.

- understand the application of different types of maintaining power to the motive force for clocks.
- Unit 6, Learning Outcomes, continued:-
- understand the principles of construction of the marine chronometer.
 - understand the action of the spring detent escapement.
 - appreciate the risk of damage to a marine chronometer unless strict dismantling procedures are followed.
 - understand the principles of the operation of calendar clocks.
 - understand the principles of temperature compensation applied to the pendulum and the balance and spring.
 - understand the principles of operation of electric clocks
 - identify suitable approaches for achieving spotted and matted surfaces on horological components.
 - understand the principles for using the turns and identify runners and attachments for various purposes.
 - evaluate different approaches to making a balance staff.
 - understand the principles of cutting wheels and pinions using “commercial” cutters and “flycutters”.
 - design and make a rack and snail for a striking clock
 - design dead beat escapement pallets for different applications
 - know the theory of making flat drills to produce holes in a variety of materials
 - understand the principle of construction and operation of the verge escapement
 - know how to identify and correct defects in the verge escapement
 - understand, commensurate with the requirements for Final Grade Part II practical units, the theoretical background of the use construction and care of hand tools and machines used in horology. (Unit 5, The Practical Repair of Clocks; Unit 7, Practical Clockmaking Techniques; Unit 8, The Practical Restoration / Conservation of Clocks
 - evaluate the use of differing approaches and materials when making and modifying complex and delicate clock and watch components

Assessment procedure:-

This unit is externally assessed, a 2½ hour examination paper, set by the Examinations Board of the British Horological Institute, assesses the candidate's knowledge and understanding of the Theory of Clocks and Clock Conservation and Restoration. Candidates are required to answer four questions from Section A and the twenty short questions in section B. BHI Examiners assess the scripts on the basis of the accuracy and depth of the content; two grades of Pass are awarded Pass (40%) and Pass with Merit (66%)

Unit 7 Final Grade, Part II : Practical Clockmaking Techniques (Clock Pathway)

Outline:-

The practical use of tools and machinery to measure, produce and modify, to very close tolerances, interacting complex and delicate brass and steel components for clocks.

Syllabus:-

- Health and safety:- personal; fellow workers; visitors
- Mark out:- from a drawing, using rule, scribe, dividers, centre punch; use of master edge
- Use hacksaw, piercing saw and files to produce flat / curved, square surfaces to required dimensions and tolerances
- Drill holes using a drilling machine; countersinking
- Use a lathe for turning cylindrical, flat and spherical surfaces (watchmaker's and centre lathe):- use of collets and chucks; centres; compound slide with lathe cutting tools; T-rest and graver; sharpen lathe tools and graver; drilling using twist and flat drills; "catching" a centre; turning and burnishing pivots; filing flats
- Use turns with runners and attachments
- Make flat drills to cut brass and steel (soft and hardened)
- Use a lathe and dividing head or wheelcutting engine with commercial and purpose made cutters to produce wheels and pinions
- Make screws:- cutting threads, internal and external (sizes down to 0.5mm); cutting screw slots; hardening and tempering screws; polishing screw threads; bluing
- Produce square holes:- punching; drilling; filing
- Make punches, cutters for counterboring etc.
- Fasten components:- using soft and hard soldering techniques, riveting, screws, adhesives

Unit 7, Syllabus, continued:-

- Produce frosted and spotted surfaces
- Form simple bends to brass and steel components
- Heat treat steel and brass:- hardening; tempering; annealing; bluing
- Design and make a dead beat escapement (wheel and pallets) given escapement data. (Graham, Brocot, and pinwheel (English and Amant/Lepaute)
- Make and fit a balance staff for a platform escapement using a variety of approaches

Learning outcomes:-

The successful candidate will be able to:-

- read drawings to measure and mark out interacting complex delicate components accurately.
- make and modify complex steel and brass clock components to within a general tolerance of + or - 0.03mm with required fits and clearances, using hand tools, a centre lathe and a watchmakers lathe. This will include the cutting of threads, hard and soft soldering, riveting, heat treatment and finishing to provide polished, grained and blued surfaces.
- produce components to pattern replace worn damaged or missing complex delicate clock components.
- design and make dead beat escapements (wheel and pallets) given escapement data.

Assessment procedure:-

This unit is externally assessed, the British Horological Institute provides each candidate with a dimensioned drawing of an escape wheel for a dead beat escapement together with shoulder screw, stud and a small plate. A period of three weeks is allocated for candidates to produce these components and design, make, adjust, harden and finish the pallets to make an operational dead beat escapement.

A declaration signed by the candidate and, where appropriate, the college tutor provides confirmation that the piece is the candidate's own work.

Unit 7, Assessment Procedure, continued:-

BHI Examiners assess the piece by considering the candidate's achievement within four broad areas:-

Action of the Escapement	(55%)
Escapement Accuracy / Quality	(27%)
Quality of Workmanship / Finish	(18%)

Two grades of pass are awarded, Pass (40%) and Pass with Merit (66%).

Unit 8 Final Grade, Part II : The Practical Conservation / Restoration of Clocks (Clock Pathway)

Outline:-

The candidate, having gained extensive background knowledge of many of the mechanisms to be found in antique and older clocks, with an appreciation of the principles of conservation and restoration, is now required to apply this knowledge and understanding to clocks requiring conservation / restoration.

This unit requires the candidate to combine:-

1. The expertise and understanding to repair mechanical clocks acquired from:-
 - a) Unit 1, Final Grade Part I : Theory of Clocks and Watches and their Repair
 - b) Unit 3, Final Grade Part II : Theory of Clocks and Watches and their Repair
 - c) Unit 4, Final Grade Part I : The Practical Repair of Clocks
 - d) Unit 5, Final Grade Part II : The Practical Repair of Clocks

and

2. The skills and knowledge necessary to produce complex and delicate replacement components for antique clocks developed from:-
 - a) Unit 2, Final Grade Part I: Practical Clock and Watchmaking Techniques
 - b) Unit 6, Final Grade Part II: The Theory of Clocks and Clock Restoration and Conservation
 - c) Unit 7, Final Grade Part II : Practical Clockmaking Techniques

Syllabus:-

- Clock identification:- identify types antique clock age; style; type of case; type of movement; escapement; research maker
- Customer care:- record customer details; give accurate estimates for repairs; record accurate details of clocks and work completed; complete research required to produce clock components
- Cleaning fluids:- select; use safely; dispose of with respect to the environment
- Lubrication, follow established principles for the selection and application of lubricants

Unit 8, Syllabus, continued:-

- Identify and correct, with a sensitivity to established conservation / restoration principles, routine faults and non-routine faults in antique and older clocks. These could include:-
 - 1) Train, going / striking:-
 - a) bush worn pivot holes, requiring the making of bushes for particular situations, use of depthing tool to check depths of wheels and pinions
 - b) repivot narrow, worn / broken pivots, including making a flat drill
 - c) incorrect endshakes
 - d) checking and truing wheels
 - e) damaged / missing wheels and pinions (make and fit replacement)
 - 2) Striking work:-
 - a) Repair / replace rack with damaged teeth
 - b) Repair / replace worn or damaged gathering pallet
 - 3) Recoil escapement (verge):-
 - a) Repair / replace worn / damaged verge pallets
 - b) Repair / replace worn damaged crown wheel
 - 4) Recoil escapement (anchor):-
 - a) Replace worn / damaged recoil escapement pallets
 - b) Repair / replace worn damaged recoil escape wheel
 - 5) Dead beat escapement:-
 - a) Replace worn / damaged dead beat escapement pallets
 - b) Repair / replace worn damaged dead beat escape wheel
 - 6) Motive force:-
 - a) Replace damaged great wheel
 - 7) Platform Escapement, club toothed lever escapement / English lever escapement, identify and correct faults:-
 - a) damaged jewels, rubbed in and pushed in jewels; use of jewellery tool reamers and pushers
 - b) worn / damaged balance staff (make and fit replacement)
 - 8) Platform escapement, cylinder escapement, identify and correct faults:-
 - a) removing and replace cylinder plugs
 - b) depthing of cylinder and escape wheel - adjusting the chariot
 - c) replacing cylinder (where possible)
 - d) replacing damaged jewels, rubbed in and pushed in jewels; use of jewellery tool reamers and pushers

Unit 8, Syllabus, continued:-

- Use hand and machine tools to mark out, produce and finish complex and delicate interacting clock parts in brass and steel:-
 - 1) hand tools:- files; saws
 - 2) machine tools:- lathe (turning and wheelcutting); milling machine; turns; jacot tool
 - 3) heat treatment:- hardening; tempering; bluing
 - 4) finishing brass and steel:- polishing; frosting

Learning Outcomes:-

The successful candidate will be able to:-

- diagnose and correct a wide range of faults in antique clocks, including:-
 - 1) train
 - 2) barrel and spring
 - 3) escapement
 - 4) balance spring
- research the style and finish of replacement components for antique clocks.
- exercise informed judgements regarding the most suitable approach to maintain the integrity of the item in the light of the varying viewpoints of the repairer, the conservator and the restorer.
- produce, fit and finish, using hand and machine tools, components for antique clocks.

Assessment Procedure:-

There are two aspects to the assessment of this unit:-

1. Internal Assessment:-

The candidate prepares a “Portfolio” detailing the work completed in the conservation / restoration of five clocks. The internal assessment requires the completion of the standard documentation similar to that necessary for Units 4 and 5 “Record of Repairs”. There is a “**List of Contents**” available to guide the candidate when selecting items for the Portfolio and to enable a list of the clocks to be recorded. A standard “**Clock Form**” is used for each item to provide basic information about the piece and the work which has been undertaken.

Each clock is internally assessed by a qualified professional member of the British Horological Institute (MBHI / FBHI).

Unit 8, Assessment Procedure, continued:-

Any clock is suitable for inclusion in the Portfolio. It is, however, necessary to ensure that the work is not merely of a routine repair nature but requires more complex repair / replacement of components / conservation. As a guide the following is required in each instance:-

- a) The inclusion of “more complex repair techniques”
- b) The replacement of at least two significant components that require manufacture by the candidate

Examples of “more complex repair techniques”:-

- 1) *Train, going / striking:-*
 - a) *bush worn pivot holes which require the making of bushes for particular situations, use of depthing tool to check **and adjust** depths of wheels and pinions*
 - b) *re-pivot narrow, worn / broken pivots, including making a flat drill*
 - c) *correct end-shakes*
 - d) *damaged wheels and pinions (make and replacement teeth)*
 - e) *truing wheels*
- 2) *Striking work:-*
 - a) *Repair rack with damaged teeth*
 - b) *Repair worn or damaged gathering pallet*
 - c) *Repair worn or damaged striking levers*
- 3) *Escapement:-*
 - a) *Repair worn damaged recoil / dead beat escape wheel*
 - b) *Platform – replace damaged jewels, rubbed in and pushed in jewels (including use of jewellery tool reamers and pushers), depthing of cylinder and escape wheel - adjusting the chariot*

Examples of “significant components” to be replaced by the candidate, these components are to be actually made by the candidate not purchased or modified components:-

- 1) *Escapement:-*
 - a) *Replace worn / damaged recoil / dead beat escapement pallets*
 - b) *Replace worn damaged recoil / dead beat escape wheel*
 - c) *Replace damaged crutch*
 - d) *Platform, make and fit replacement balance staff, make and fit replacement cylinder plugs*
- 2) *Train:-*
 - a) *Replace damaged great wheel / train wheel*
 - b) *Replace arbor and pinion*
- 3) *Striking work:-*
 - a) *Make and fit new rack*
 - b) *Make and fit new gathering pallet*
 - c) *Replacement striking lever*

External Verification / Assessment:-

Verification of the Portfolio:-

Each clock has already been internally assessed by a qualified professional member of the British Horological Institute (MBHI / FBHI). The “Portfolio” is checked by the BHI Senior Examiner to ensure that the required number of items has been conserved / restored, every item has been approved to indicate that the work was undertaken to a high standard and the nature of the work complies with the guidelines. Proforma, summarise the requirements and assist the verification process. (“List of Contents” for the Portfolio summarises the conservation / restoration items; a “Clock Form” gives basic documentation for each clock)

Assessment of the Supplementary Information in the Portfolio:-

The basic documentation required using the “Clock Form” is supplemented by the candidate with written material, sketches and / or photographs giving, for each item, details of :-

- a. Appraisal
- b. The Conservation / Restoration Process
- c. A Justification of the Conservation / Restoration Approach
- d. Research

Further guidance concerning this Supplementary Information is available in the Handbook providing examples of specimen papers

The Portfolio is initially checked and if found to meet the examination requirements a Pass is awarded. Any supplementary is then assessed by two Examiners who award marks for:-

- a. Depth of supplementary information
- b. Quality of content
- c. Use of photographs / drawings / sketches
- d. Approach to restoration / conservation

A candidate will be awarded a Pass with Merit if the Portfolio is of the required standard.

If the required number of items has not been presented, the forms are incomplete or the work does not conform to the guidelines, the Portfolio will be returned with a note of explanation.

A candidate may, on payment of the examination fee, resubmit a Portfolio which has been found to be “incomplete”.

Two grades of Pass are awarded Pass (40%) and Pass with Merit (66%).

The five clocks may also be included in the Record of Repairs required for Unit 5, Final Grade, Part II : The Practical Repair of Clocks.

Unit 9 Final Grade, Part I : The Practical Repair of Watches (Watch Pathway)

Outline:-

The practical repair of basic and complex quartz watches and manual winding mechanical watches, larger calibres (7¾ ligne or larger)

Syllabus:-

General:-

- Watch identification:- identify types of complex quartz watches by calibre number and case number
- Customer care:- record customer details; give accurate estimates for repairs; record accurate details of watches and work completed
- Case refurbishment:-
 - 1) select and fit watch glasses
 - 2) removing and replacing pushers and tubes
 - 3) remove, replace and shorten straps and bracelets
 - 4) polishing and satin finishing case parts
- Button and stem:- remove, select and replace, new stems and water resistant, dust proof and ordinary buttons to mechanical watches and basic and complex quartz watches
- Water resistance:- renew a variety of water resistant seals to buttons, pushers, glasses and case back as appropriate; execute water resistance tests by a variety of methods to establish water resistance according to international standards

Basic and complex quartz analogue watches, including alarm, stop watches, chronographs:-

- Cleaning fluids:- select; use safely; dispose of with respect to the environment
- Lady's and gents basic and complex quartz analogue watches including multi step motor type:- dismantle; clean; reassemble; lubricate; test

Unit 9, Syllabus, Basic and Complex Quartz Analogue Watches, continued:-

- Diagnose faults in basic and complex quartz analogue watches, use appropriate diagnostic test equipment to make appropriate electrical tests including:- consumption; continuity; lower working voltage limit; grounding switch; resistance; testing watch batteries under appropriate load
- Timing:- use diagnostic test equipment to check rate and regulate; use different gate settings
- Identify defective components, select and fit replacement
- Identify watch batteries:- remove, select and fit replacement batteries
- Kinetic and solar watches:- understand power generation; check charging voltage
- Lubrication:- follow manufacturer's and other guidelines for the selection and application of lubricants to train, step motors and setting mechanism

Manual winding mechanical watches:-

- Cleaning fluids:- select; use safely; dispose of with respect to the environment
- Lady's and gents wrist watches and pocket watches, manual wind:- dismantle; clean; reassemble; lubricate; test and adjust
- Use of timing machine for mechanical watches with a different train counts and lift angles:- check rate; regulate; adjust beat; identify faults
- Lubrication, follow manufacturer's and general guidelines for the selection and application of lubricants to:- springs; pivots; shockproof settings; escapements
- Identify and correct train faults:-
 - 1) Identifying worn and damaged jewels, pivot holes and pivots
 - 2) Replacing damaged jewels, including use of jewellery tool reamers and pushers
 - 3) Checking and adjusting end shakes
 - 4) Dismantling, cleaning and reassembling shockproof settings
 - 5) Replacing springs to shock proof settings
 - 6) Checking condition of wheels and pinions
 - 7) Checking and truing wheels

Unit 9, Syllabus, Manual Winding Mechanical Watches, continued:-

- Identify and correct barrel and spring faults:-
 - 1) Checking and adjusting barrel arbor end shake
 - 2) Checking arbor end shake between barrel bridge and plate
 - 3) Selecting suitable replacement spring according to calibre and barrel dimensions
 - 4) Fitting spring using mainspring winder
 - 5) Adjusting eye

- Identify and correct winding and hand setting mechanism faults:-
 - 1) Checking parts for wear, damage, burrs
 - 2) Identifying any replacement components required; specify replacement by part name and number
 - 3) Reassembling; checking parts
 - 4) Checking and adjusting cannon pinion tightness

- Identify and correct escapement faults
 - 1) Horn shake:-
 - a) Checking horn shake:-
 - Equal both sides
 - Less than total lock
 - Greater than run to banking
 - b) Correcting horn shake faults

 - 2) Guard pin shake:-
 - a) Checking guard pin shake:-
 - Equal both sides
 - Less than or equal to horn shake
 - b) Correcting guard pin faults

 - 3) Locking:-
 - a) Checking “virtual” or “drop” lock
 - $1\frac{1}{2}^\circ$ or $\frac{1}{4}$ to $\frac{1}{5}$ of pallet impulse plane
 - b) Correcting locking faults

 - 4) Run to the banking and draw:-
 - a) Checking run to the banking and draw:-
 - $\frac{1}{2}^\circ$
 - less than horn shake
 - draw causes lever to move to banking pin
 - b) Correcting run to the banking and draw

Unit 9, Syllabus, Manual Winding Mechanical Watches, continued:-

- Identify and correct balance spring faults:-
 - 1) Flatness
 - a) At the collet
 - b) At the cock
 - 2) Centring
 - a) At the collet
 - b) At the cock
 - 3) Curb pins
 - 4) Beat
 - 5) Rate
 - 6) Minor distortion

- Calendar work, gradual and instantaneous calendar work:- dismantle, identify and correct faults, reassemble and lubricate

Learning Outcomes:-

The successful candidate will be able to:-

- dismantle, clean, reassemble, lubricate and adjust quartz watches (including complex quartz watches) and manual winding mechanical watches (7³/₄ ligne and larger)

- conduct appropriate tests on quartz and mechanical watches to diagnose faults and determine conformity with standards of accuracy

- diagnose and correct faults in quartz watches:-
 - 1) electrical
 - 2) mechanical

- diagnose and correct faults in manual winding mechanical watches (7³/₄ ligne and larger)
 - 1) train
 - 2) barrel and spring
 - 3) winding and handsetting
 - 4) escapement
 - 5) balance spring

Unit 9, continued:-

Assessment Procedure:-

There are two aspects to the assessment of this unit:-

1. Internal assessment – the candidate prepares a “Record of Repairs” detailing the work completed when repairing ten watches
2. External assessment – the candidate repairs two watches (a quartz watch and a gent’s manual winding mechanical watch)

1. Internal Assessment : Record of Repairs:-

Candidates are required to produce a “Record of Repairs” describing the repair of ten watches completed within a two year period immediately prior to examination entry. Each item repaired by a candidate must be documented and checked by a qualified member of the Institute (MBHI / FBHI).

Forms, which are available from Upton Hall, must be used for documentation:-

- **“List of Contents”**, Final Grade Part I : Unit 9, summarises the work completed and acts as an aide memoire ensuring the candidate completes the necessary number of repairs and the fundamental repair processes. The “List of Contents” gives:-
 - a. The number of repairs required together with advice concerning the type of watches
 - b. The specific “repair processes” required
- **For each item that has been repaired** a separate form, a **“Mechanical Watch Form”** or **“Quartz Watch Form”**, must be used to record a description of the item, faults noted, repair work undertaken etc..

If any process does not occur when repairing the watches the candidate must undertake the process as an exercise, document the exercise on a form and, after ensuring that the assessor has checked the process, enclose it with the Record of Repairs. The Assessor Guidance Notes are included, together with further details about the Record of Repairs, in the “Examination Handbook for the Distance Learning Course”, to be found at the front of your copy of the course, and also in “Specimen Papers :- Certificate in the Repair, Restoration and Conservation of Clocks / Watches”. Copies of the forms are provided by the Institute and may be photocopied as required.

2. External Verification / Assessment:-

Verification of the Record of Repairs:-

Each watch has already been internally assessed by qualified professional member of the British Horological Institute (MBHI / FBHI or equivalent approved by the Examinations Board.) The “Record of Repairs” is verified by the BHI Senior Examiner to ensure that the required number of items has been repaired, every item has been approved to indicate that the work was undertaken to a high standard and the nature of the work complies with the guidelines. A Pass is awarded if the “Record of Repairs” is “complete”. The unit is thus competence based and marks are not awarded

Servicing and Repairing two movements:-

The candidate is allocated twelve hours to repair two watches; one quartz watch and one gent's mechanical wrist watch are provided, each with introduced faults. The candidate is required to diagnose and correct the faults and service the watches thus involving the use of test equipment, dismantling, checking the components, re-assembly, lubrication and adjustment.

BHI Examiners assess the repaired movements on the basis of the candidate's identification and correction of the faults and the quality of the servicing activity; two grades of Pass are awarded Pass (40%) and Pass with Merit (66%).

It is necessary for the candidate to submit a Record of Repairs that fulfils the requirements of the syllabus.

Providing the candidate gains a Pass for the Record of Repairs, the overall result, a Pass (40%) or a Pass with Merit (66%), is determined from:-

- a) repairing the quartz watch (contributing max. 50%)**
- b) repairing the mechanical watch (contributing max. 50%)**
- c) a Pass (40%) must be gained for both the quartz watch and the mechanical watch movement if the candidate is to awarded a Pass for Unit 9:-**
 - i) quartz watch, i.e. a minimum of 20 marks out of the possible maximum of 50 marks**
 - ii) mechanical watch, i.e. a minimum of 20 marks out of the possible maximum of 50 marks**

Unit 9, continued:-

Summary of the requirements for Unit 9, Final Grade Part I : The Practical Repair of Watches – Internal assessment (Record of Repairs) and External Assessment:-

Number of repairs required / guidance regarding type of repair, etc.	Repair Procedures / Processes
<p>A total of ten watch / movement repairs involving, in each instance, a full service not just a “part job”.</p> <p>This must include:-</p> <ol style="list-style-type: none"> 1. At least one basic and one complex quartz watch / movement 2. At least five mechanical watches / movements (7¾ ligne or larger) 3. At least five “cased” movements <p>External assessment:- (In addition to Record of Repairs for Unit 9, Final Grade I : The Practical Repair of Watches) Repair and service one quartz watch and one gent’s mechanical wrist watch, each with introduced faults. (Time allocated : 12 hours)</p>	<p>The repair of quartz watches / movements requires in each instance:- Use of test equipment to:-</p> <ol style="list-style-type: none"> 1. diagnose faults in quartz watches 2. test the completed repair <p>The repair of mechanical watches / movements requires in each instance:-</p> <ol style="list-style-type: none"> 1. Use of test equipment to diagnose faults in mechanical watches, adjust for rate and beat 2. Cleaning and lubricating jewel holes and endstones in shockproof or other settings 3. Lever escapement, check for faults and correct if necessary:- <ol style="list-style-type: none"> a) Horn shake b) Guard pin shake c) Locking d) Run to the banking 4. Balance spring, check for faults and correct if necessary:- <ol style="list-style-type: none"> a) Flatness at collet and cock b) Centring at collet and cock c) Curb pins d) Beat e) Rate f) Minor distortion g) Magnetism <p>The following repair processes must be included in the repairs or as exercises:-</p> <ol style="list-style-type: none"> 1. Adjust cannon pinion tightness 2. Water resistance testing:- <ol style="list-style-type: none"> a) Two methods b) Condensation test 3. Maintain shockproof settings:- <ol style="list-style-type: none"> a) Clean and oil two different types of shockproof settings b) Replace shock springs 4. Friction jewels:- <ol style="list-style-type: none"> a) Replace friction jewels b) Adjust end shake

Unit 10 Final Grade, Part II : The Practical Repair of Watches (Watch Pathway)

Outline:-

The practical repair of manual winding and automatic winding mechanical watches including smaller calibres. (smaller than 7¾ ligne)

Syllabus:-

General

(Some of the following general areas are listed in Unit 9, Final Grade, Part I : The Practical Repair of Watches, but are now applied to the smaller more delicate calibres below 7¾ ligne):-

- Watch identification:- identify types by calibre number and case number
- Customer care:- record customer details; give accurate estimates for repairs; record accurate details of watches and work completed
- Case refurbishment:-
 - 1) Select and fit watch glasses
 - 2) Removing and replacing pushers and tubes
 - 3) Remove, replace and shorten straps and bracelets
 - 4) Polishing and satin finishing case parts
- Button and stem, remove, select and replace:- stems; water resistant, dust proof and ordinary buttons
- Water resistance:- renew a variety of water resistant seals to buttons, glasses and case backs; execute water resistance tests by a variety of methods to establish water resistance according to international standards
- Removal and replacement of balance staff:-
 - 1) Identify need for replacement balance staff (broken, damaged or worn pivots)
 - 2) Remove balance spring and roller, noting position of components
 - 3) Remove existing balance staff:-
 - a) Pressing out staff using staking set
 - b) Turning away rivet / balance seating
 - 4) Check for burrs to balance and correct if necessary
 - 5) Verify suitability of replacement staff
 - 6) Press balance onto replacement staff using staking tool

Unit 10, Syllabus, Removal and Replacement of Balance Staff, continued:-

- 7) Rivet balance securely, where appropriate, using staking tool
 - 8) Use callipers to true the balance
 - 9) Poise balance assembly
 - 10) Refit balance spring
- Dynamic poising

Manual winding mechanical watches

(The following general areas, listed in Unit 2, Final Grade, Part I : The practical Repair of Watches, but applied to calibres smaller than 7¼ ligne):-

- Cleaning fluids:- select; use safely; dispose of with respect to the environment
- Lady's wrist watches, manual wind:- dismantle; clean; reassemble; lubricate; adjust
- Use of timing machine for mechanical watches with a different train counts and lift angles:- check rate; regulate; adjust beat; identify faults
- Lubrication, follow manufacturer's and other guidelines for the selection and application of lubricants to:- springs; pivots; shockproof settings; escapements
Use of epilame.
- Identify and correct train faults:-
 - 1) Identifying worn and damaged jewels, pivot holes and pivots
 - 2) Replacing damaged jewels, including use of jewellery tool reamers and pushers
 - 3) Checking and adjusting end shakes
 - 4) Dismantling, cleaning and reassembling shockproof settings
 - 5) Replacing springs to shock proof settings
 - 6) Checking condition of wheels and pinions
 - 7) Checking and truing wheels
- Identify and correct barrel and spring faults:-
 - 1) Checking and adjusting barrel arbor end shake
 - 2) Checking arbor end shake between barrel bridge and plate
 - 3) Selecting suitable replacement spring according to calibre and barrel dimensions
 - 4) Fitting spring using mainspring winder
 - 5) Adjusting eye

Unit 10, Syllabus, Manual Winding Mechanical Watches, continued:-

- Identify and correct winding and hand setting mechanism faults:-
 - 1) Checking parts for wear, damage, burrs
 - 2) Identifying any replacement components required, specify replacement by part name and number
 - 3) Reassembling, and checking parts
 - 4) Checking and adjusting cannon pinion tightness

- Identify and correct escapement faults:-
 - 1) Horn shake:-
 - a) Checking horn shake:-
 - Equal both sides
 - Less than total lock
 - Greater than run to banking
 - b) Correcting horn shake faults

 - 2) Guard pin shake:-
 - a) Checking guard pin shake:-
 - Equal both sides
 - Less than or equal to horn shake
 - b) Correcting guard pin faults

 - 3) Locking:-
 - a) Checking “virtual” or “drop” lock
 - $1\frac{1}{2}^\circ$ or $\frac{1}{4}$ to $\frac{1}{5}$ of pallet impulse plane
 - b) Correcting locking faults

 - 4) Run to the banking and draw:-
 - a) Checking run to the banking and draw:-
 - $\frac{1}{2}^\circ$
 - less than horn shake
 - draw causes lever to move to banking pin
 - b) Correcting run to the banking and draw

- Identify and correct balance spring faults:-
 - 1) Flatness:-
 - a) At the collet
 - b) At the cock
 - 2) Centring:-
 - a) At the collet
 - b) At the cock
 - 3) Curb pins:-
 - 4) Beat
 - 5) Rate
 - 6) Minor distortion

Unit 10, Syllabus, Manual Winding Mechanical Watches, continued:-

- Calendar work, gradual and instantaneous calendar work:- dismantle; identify and correct faults; reassemble; lubricate

Automatic winding watches:-

- Gent's and lady's wrist watches, automatic winding:- dismantle; clean; reassemble; lubricate; adjust
- Identify and correct faults in automatic winding work:-
 - 1) Check oscillating weight revolves freely
 - 2) Check end shakes
 - 3) Check winding of watch, one or both directions as applicable
 - 4) Check action of bridle, slip spring for "creep"
 - 5) Checking the winding rate

Chronograph / stopwatch:-

- Chronographs / stopwatches:- dismantle; clean; reassemble; lubricate; adjust
- Identify and correct faults in chronograph mechanisms:-
 - 1) Checking:-
 - a) Control functions
 - b) Seconds transfer function
 - c) Minute counting function
 - d) Zero reset, flyback, function of seconds and minutes counter
 - 2) Adjust eccentric plugs:-
 - a) Chronograph bar
 - b) Depth between transmission wheel and chronograph wheel
 - c) Depth of minute recording finger and intermediate minute wheel

Learning Outcomes:-

The successful candidate will be able to:-

- dismantle, clean, reassemble, lubricate and adjust manual winding and automatic winding mechanical watches including 5¾ ligne
- diagnose and correct faults in manual winding and automatic winding mechanical watches, including 5¾ ligne
 - 1) train
 - 2) barrel and spring
 - 3) winding and handsetting
 - 4) escapement
 - 5) balance spring

Unit 10, Learning Outcomes, continued:-

- dismantle, clean, reassemble, lubricate and adjust chronographs and stopwatches
- diagnose and correct faults in chronographs and stopwatches
- remove and replace balance staffs, true and poise the balance
- check accuracy of dynamic poising and correct if necessary

Assessment Procedure:-

There are two aspects to the assessment of this unit:-

1. Internal assessment – the candidate prepares a “Record of Repairs” detailing the work completed when repairing fifteen watches
2. External assessment – the candidate repairs two watches (an automatic winding watch and a stopwatch / chronograph)

1. Internal Assessment : Record of Repairs:-

Candidates are required to produce a “Record of Repairs” describing the repair of fifteen watches completed within a two year period immediately prior to examination entry.

Each item repaired by a candidate must be documented and checked by a qualified member of the Institute (MBHI / FBHI).

Forms, which are available from Upton Hall, must be used for documentation:-

- **“List of Contents”**, Final Grade Part II : Unit 10, summarises the work completed and acts as an aide memoire ensuring the candidate completes the necessary number of repairs and the fundamental repair processes. The “List of Contents” gives:-
 - a. The number of repairs required together with advice concerning the type of watches
 - b. The specific “repair processes” required
- **For each item that has been repaired** a separate form, a **“Mechanical Watch Form”** or **“Quartz Watch Form”**, must be used to record a description of the item, faults noted, repair work undertaken etc..

If any process does not occur when repairing the watches the candidate must undertake the process as an exercise, document the exercise on a “Mechanical Watch Form” or “Quartz Watch Form”, after ensuring that the assessor has checked the process, enclose the form with the Record of Repairs. The Assessor Guidance Notes are included, together with further details about the Record of Repairs, in the “Examination Handbook for the Distance Learning Course”, to be found at the front of your copy of the course, and also in “Specimen Papers:- Certificate in the Repair, Restoration and Conservation of Clocks / Watches”. Copies of the forms are provided by the Institute and may be photocopied as required.

2. External Verification / Assessment:-

Verification of the Record of Repairs:-

Each watch has already been internally assessed by qualified professional member of the British Horological Institute (MBHI / FBHI or equivalent approved by the Examinations Board.) The “Record of Repairs” is verified by the BHI Senior Examiner to ensure that the required number of items has been repaired, every item has been approved to indicate that the work was undertaken to a high standard and the nature of the work complies with the guidelines. A Pass is awarded if the “Record of Repairs” is “complete”. The unit is thus competence based and marks are not awarded

Servicing and Repairing two movements:-

The candidate is allocated twelve hours to repair the two watches; one automatic winding watch and one stopwatch / chronograph are provided, each with introduced faults. The candidate is required to diagnose and correct the faults and service the watches thus involving the use of test equipment, dismantling, checking the components, re-assembly, lubrication and adjustment.

BHI Examiners assess the repaired movements on the basis of the candidate’s identification and correction of the faults and the quality of the servicing activity.

It is necessary for the candidate to submit a Record of Repairs that fulfils the requirements of the syllabus.

Providing the candidate gains a Pass for the Record of Repairs, the overall result, a Pass (40%) or a Pass with Merit (66%), is determined from:-

- a) **repairing the automatic winding watch (contributing max. 50%)**
- b) **repairing the stopwatch / chronograph (contributing max. 50%)**
- c) **a Pass (40%) must be gained for both the automatic winding watch and the stopwatch / chronograph if the candidate is to be awarded a Pass for Unit 10**
 - i) **stopwatch /chronograph, i.e. a minimum of 20 marks out of a possible maximum of 50 marks**
 - ii) **automatic watch, i.e. a minimum of 20 marks out of a possible maximum of 50 marks**

Unit 10, continued:-

Summary of the requirements for Unit 10, Final Grade Part II : The Practical Repair of Watches – Internal assessment (Record of Repairs) and External Assessment:-

Number of repairs required / guidance regarding type of repair, etc.	Repair Procedures / Processes
<p>A total of fifteen watch / movement repairs involving, in each instance, a full service not just a “part job”.</p> <p>This must include:-</p> <ol style="list-style-type: none"> 1. No more than two quartz watches 2. More than one automatic winding watch / movement 3. At least five mechanical watches / movements (smaller than 7¾ ligne) 4. A chronograph <p>External assessment:- (In addition to Record of Repairs for Unit 10, Final Grade II : The Practical Repair of Watches) Repair and service one automatic watch and one stopwatch, each with introduced faults (Time allocated : 12 hours)</p>	<p>The repair of mechanical watches / movements requires in each instance:-</p> <ol style="list-style-type: none"> 1. Use test equipment to diagnose faults in mechanical watches, adjust for rate and beat 2. Lever escapement, check for faults and correct if necessary:- <ol style="list-style-type: none"> a) Horn shake b) Guard pin shake c) Locking d) Run to the banking 3. Balance spring, check for faults and correct if necessary:- <ol style="list-style-type: none"> a) Flatness at collet and cock b) Centring at collet and cock c) Curb pins d) Beat e) Rate f) Minor distortion g) Magnetism <p>The following repair processes must be included in the repairs or as exercises:-</p> <ol style="list-style-type: none"> 1. Replace a balance staff, including truing and poising 2. Check dynamic poising and correct if necessary 3. Replace and adjust pallet jewels to ensure correct locking and run to the banking 4. Adjust guard pin shake 5. Correcting balance spring faults <ol style="list-style-type: none"> a) Flatness at collet and cock b) Centring at collet and cock 6. Make adjustments to faults in depthing of chronograph mechanism

Unit 11 Final Grade, Part II : The Theory of Watches and Watch Restoration and Conservation (Watch Pathway)

Outline:-

This unit provides extensive background knowledge of many of the mechanisms to be found in antique and older watches. It enables the student to gain detailed information about the processes required to make and modify components for watches where replacement components are not available. The unit thus provides the underpinning knowledge for the practical conservation / restoration of watches in Unit 13, Final Grade Part II : The Practical Conservation / Restoration of Watches.

It is essential that the candidate has completed:-

Unit 1, Final Grade Part I : The Theory of Clocks and Watches and their Repair

and has completed **or** is preparing for:-

Unit 3, Final Grade Part II : The Theory of Clocks and Watches and their Repair.

N.B. The Institute has provided revised “Contents” pages for the Preliminary, Intermediate and Final Grade Distance Learning Courses. These “Contents” pages give detailed references for the material which is to be examined in this Unit. There are slight differences between the topics listed in this syllabus and the sections present in the “Contents” pages - some theoretical topics within the sections “Clocks” and “Watches” are not present in the Distance Learning Course, these will, in time, be included. **The examination paper, during the interim period, will only include questions focusing on those theoretical topics in the sections “Clocks” and “Watches” which are present in the Distance Learning Course together with practical questions relating to “Clocks”, “Watches” and “Workshop Processes”.**

Syllabus:-

Time Determination:-

- Background:-
 - 1) Fundamental units
 - 2) Mean solar and sidereal time
 - 3) The earth as a clock
 - 4) Longitude and time zone
 - 5) Determination of clock error
 - 7) IERS

Unit 11, Syllabus, continued:-

Watches, historical and constructional details for antique and older watches:-

- Watch cases:-
 - 1) Early watch cases; dials and hands; glasses
 - 2) Construction of watch cases
 - 3) Early waterproof watch cases
 - 4) Materials used in the manufacture of watch cases
 - 5) Sizes of watch cases
- The evolution of the watch:-
 - 1) Full plate, half plate watches
 - 2) Development of the watch escapement, verge, cylinder, duplex, lever
 - 3) Development of self winding watches
 - 4) Early calendar watches
- The power source:-
 - 1) Barrel assembly, methods of mainspring hooking
 - 2) Clickwork, recoiling click, solid click for fusee barrel arbor
 - 3) Fusee assembly:- description, construction, function and names of components
 - 4) Geneva stopwork
 - 5) Stackfreed
 - 6) Safety devices
 - 7) Mainspring calculations
 - 8) Tapered mainsprings
- Keyless work:-
 - 1) Historical background
 - 2) Types of keyless work, rocking bar, push piece, fusee
 - 3) Negative set keyless work
- The train, calculation of missing wheels and pinions
- Pivots and bearings :-
 - 1) Defects in pivots
 - 2) Size and strength of pivots; materials
 - 3) Cone pivots; bearings for cone pivots
 - 4) Broaching and bushing worn pivot holes
- Balance and Spring:-
 - 1) How a balance spring is produced
 - 2) Properties of the spring – Hooke's Law
 - 3) Limit of elasticity; moment of elasticity; Young's Modulus of Elasticity
 - 4) Compensation
 - 5) Production of a bimetallic balance

Unit 11, Syllabus, Watches, continued:-

- Escapements:-
 - 1) Duplex escapement, historical background, construction and action
 - 2) Lever escapement, historical background, different types of lever escapement; Thomas Mudge; George Savage
 - 3) Daniel's escapement

- Gearing:-
 - 1) Epicyclic gearing
 - 2) Rotating escapements, e.g. tourbillon, carousel
 - 3) Wolf tooth gearing

- Electronic watch:-
 - 1) Tuning fork watch
 - 2) Electrically impulsed balance

- Calendar Watches:-
 - 1) Perpetual calendar watch
 - a) Forty eight month cam
 - b) Twelve month cam

- The marine chronometer:-
 - 1) Historical background
 - 2) Description and function of components
 - 3) Spring detent escapement:-
 - a) Description and function of components
 - b) Action
 - c) Adjustments

- Watches with striking mechanisms:-
 - 1) Minute repeating watches:- description; operation

- Principles of conservation and restoration (Conservation of Clocks and Watches edited by P B Wills):-
 - 1) Ethics for the repair and restoration process
 - 2) Records and documentation
 - 3) Principles and objectives
 - 4) Principles of conservation and restoration
 - 5) Conservation

Unit 11, Syllabus, continued:-

Workshop Processes:-

- Hand and machine processes to produce delicate watch components:-
 - 1) care and use of and tools for marking out and cutting brass and steel
 - 2) care and use of centre and watchmakers lathes including attachments
 - 3) care and use of the turns, runners and attachments
 - 4) hardening and tempering steel
 - 5) finishing techniques:-
 - a) Producing spotted finishes on brass
 - b) Producing frosted finishes on brass and steel

- Materials used in watchmaking:-
 - 1) Properties of materials
 - 2) Ferrous metals:-
 - a) Iron
 - b) Steel, stainless steel

 - c) Invar; elinvar
 - d) Brass:-
 - i Properties
 - ii Types of brass
 - iii Nickel Brass
 - e) Bronzes; copper; zinc; tin; copper beryllium alloys; aluminium
 - f) Precious and semi-precious materials
 - g) Hard precious or semi-precious stones
 - h) Solder
 - i) Shellac

- Flat drills:-
 - 1) Cutting angles for flat drills
 - 2) Making flat drills for brass, steel and hardened steel

- Techniques for turning a balance staff :-
 - 1) Turning in a collet – one stage
 - 2) Turning in a collet – two stages
 - 3) Turning in two stages – collet and wax chuck

- Identification and correction of complex watch:-
 - 1) Train:-
 - a) Bushing pivot holes; redepthing; use of depthing tool
 - b) Repivoting; refitting / replacement of wheels; replacement of pinions
 - 2) Lever escapement:- horn shake; guard pin shake; virtual locking; run to banking; draw; pivots; jewel holes; pallet jewels
 - 3) Cylinder escapement:- replacement of pivot plugs; depthing; jewel holes

Learning Outcomes:-

The successful candidate will be able to:-

- show an appreciation of the conflicting demands when repairing / conserving / restoring watches.
- appreciate the historical development of the watch and watch escapement.
- understand the construction and operation of mechanisms in antique and older watches.
- understand of the principles of the conservation and restoration of watches.
- diagnose and correct faults in antique and older watches.
- understand the principles of compensation and the adjustment of watches.
- understand the techniques required to make and modify delicate components for antique and older watches.

Workshop Processes:-

- understand, commensurate with the requirements for Final Grade Part II practical units, the theoretical background to the use construction and care of machines used in horology. (Unit 10, The Practical Repair of Watches; Unit 12, Practical Watchmaking Techniques; Unit 13, The Practical Restoration / Conservation of Watches)
- evaluate the use of differing approaches and materials when making and modifying complex and delicate watch components

Assessment procedure:-

This unit is externally assessed; a 2½ hour examination paper, set by the Examinations Board of the British Horological Institute, assesses the candidate's knowledge and understanding of the Theory of Watches and Watch Conservation and Restoration. Candidates are required to answer four questions from Section A and the twenty short questions in section B.

BHI Examiners assess the scripts on the basis of the accuracy and depth of the content; two grades of Pass are awarded Pass (40%) and Pass with Merit (66%).

Unit 12 Final Grade, Part II : Practical Watchmaking Techniques (Watch Pathway)

Outline:-

The practical use of tools and machinery to measure, produce and modify, to close tolerances, interacting complex and delicate components for watches from brass and steel.

Syllabus:-

- Health and safety:- personal; fellow workers; visitors
- Mark out:- from a drawing, using rule, scribe, dividers, centre punch; use of master edge
- Use hacksaw, piercing saw and files to produce to required dimensions and tolerances:- straight; flat; curved; square surfaces
- Drill holes using a drilling machine, countersinking
- Use of a lathe (watchmaker's and centre lathe) for turning cylindrical, flat and spherical surfaces:- use of collets and chucks; centres; compound slide, with lathe cutting tools; T-rest and graver; sharpen lathe tools and graver; drilling using twist and flat drills; "catching" a centre; turning and burnishing pivots; filing flats
- Use turns with runners and attachments
- Make flat drills to cut brass and steel (soft and hardened)
- Use a lathe and dividing head or wheelcutting engine with commercial and purpose made cutters to produce wheels
- Make screws:- cutting threads, internal and external (sizes down to 0.3mm); cutting screw slots; hardening and tempering screws; polishing screw threads; bluing
- Produce square holes:- punching; drilling; filing
- Make punches, cutters for counterboring etc.
- Fasten components:- riveting, screws, adhesives

Unit 12, Syllabus, continued:-

- Produce frosted and spotted surfaces
- Form simple bends to brass and steel components
- Heat treat steel and brass:- hardening, tempering annealing, bluing

Learning outcomes:-

The successful candidate will be able to:-

- read drawings to measure and mark out interacting complex delicate components accurately
- make and modify complex steel and brass watch components to within a general tolerance of + or - 0.03mm with required fits and clearances using hand tools, a centre lathe, a watchmakers lathe and to include the cutting of threads, riveting, heat treatment and finishing to provide polished, grained frosted and blued surfaces
- produce components to pattern; replace worn, damaged or missing complex delicate watch components

Assessment procedure:-

This unit is externally assessed, the British Horological Institute provides each candidate with a pocket / wrist watch with stem missing; the candidate is required to make a stem and other component/s e.g. keyless cover; the watch must be serviced and adjusted. The candidate is also required to make and fit a balance staff to a watch / platform escapement. A period of three weeks is allocated for candidates to produce the components.

A declaration signed by the candidate and, where appropriate, the college tutor provides confirmation that the piece is the candidate's own work.

BHI examiners assess the piece by considering the candidate's achievement within four broad areas:-

Operation	(30%)
Accuracy	(20%),
Quality of workmanship	(20%)
Finish	(30%)

Two grades of pass are awarded, Pass (40%) and Pass with Merit (66%).

Unit 13 Final Grade, Part II : The Practical Restoration of Watches (Watch Pathway)

Outline:-

The candidate, having gained extensive background knowledge of many of the mechanisms to be found in antique and older watches, with an appreciation of the principles of conservation and restoration, is now required to apply this knowledge and understanding to watches requiring conservation / restoration.

This unit requires the candidate to combine:-

1. The expertise and understanding to repair mechanical watches where interchangeable parts are available, acquired from:-
 - a) Unit 1, Final Grade Part I : Theory of Clocks and Watches and their Repair
 - b) Unit 3, Final Grade Part II : Theory of Clocks and Watches and their Repair
 - c) Unit 9, Final Grade Part I : The Practical Repair of Watches
 - d) Unit 10, Final Grade Part II : The Practical Repair of Watches

and

2. The skills and knowledge necessary to produce complex and delicate replacement components for antique and older watches, developed from:-
 - a) Unit 2, Final Grade Part I: Practical Clock and Watchmaking Techniques
 - b) Unit 11, Final Grade Part II: The Theory of Watches and Watch Restoration and Conservation
 - c) Unit 12, Final Grade Part II : Practical Watchmaking Techniques

Syllabus:-

- Watch identification:- identify types of older watch, by age; style; type of case; type of movement (full plate, quarter plate etc.); escapement; power source, fusee / going barrel
- Customer care:- record customer details; give accurate estimates for repairs; record accurate details of watches and work completed; complete research required to produce watch components
- Case refurbishment:-
 - 1) Select and fit watch glasses
 - 2) Refinish watch cases
 - 3) Complete minor repairs to watch cases

Unit 13, Syllabus, continued:-

- Use of timing machine for mechanical watches with a different train counts and lift angles:- check rate; regulate; adjust beat; identify faults
- Lubrication, follow manufacturer's and other guidelines for the selection and application of lubricants to:- springs; pivots; shockproof settings; escapements
- Identify and repair, with a sensitivity to established conservation / restoration principles, routine faults and the following non routine faults in antique and older watches:-
 - 1) Train faults:-
 - a) Bush worn pivot holes; use of depthing tool to check depths of wheels and pinions
 - b) Replacing damaged jewels, rubbed in and pushed in jewels; use of jewellery tool reamers and pushers
 - c) Repivot worn / broken pivots
 - d) Checking and adjusting end shakes
 - e) Checking condition of wheels and pinions
 - f) Checking and truing wheels
 - 2) Motive force:-
 - a) Checking and adjusting end shakes
 - b) Making and fitting new barrel hooking
 - c) Forming new eye / resilient hooking / end piece to mainspring
 - d) Selecting and fitting suitable replacement spring according to calibre and barrel dimensions
 - e) Dismantle and reassemble fusee assembly
 - f) Replace fusee clicks
 - 3) Winding and hand setting mechanism faults:-
 - a) Checking parts for wear, damage, burrs
 - b) Reassembling, and checking parts
 - c) Checking and adjusting cannon pinion tightness, indentation and slotted
 - 4) Club toothed lever escapement / English lever escapement, identify and correct faults:-
 - a) Horn shake
 - b) Guard pin shake
 - c) Locking
 - d) Run to the banking and draw
 - 5) Cylinder escapement, identify and correct faults:-
 - a) Removing and replacing cylinder plugs
 - b) Depthing of cylinder and escape wheel - adjusting the chariot
 - c) Replacing cylinder, where possible

Unit 13, Syllabus, continued:-

- 6) Balance spring faults, identify and correct faults:-
 - a) Flatness
 - b) Centring
 - c) Curb pins
 - d) Beat
 - e) Rate
 - f) Distortion
- Use hand and machine tools to mark out, produce and finish delicate interacting watch parts in brass and steel:-
 - 1) hand tools:- files; saws
 - 2) machine tools:- lathe (turning and wheelcutting); milling machine, turns, jacot tool
 - 3) heat treatment:- hardening; tempering; bluing
 - 4) finishing brass and steel:- polishing; frosting

Learning Outcomes:-

The successful candidate will be able to:-

- dismantle, clean, reassemble, lubricate and adjust antique and older mechanical watches
- diagnose and correct faults in antique and older mechanical watches, including:-
 - 1) train
 - 2) barrel and spring
 - 3) winding and handsetting
 - 4) escapement
 - 5) balance spring
- research the style and finish of replacement components for antique and older watches.
- exercise informed judgements regarding the most suitable approach to maintain the integrity of the item in the light of the varying viewpoints of the repairer, the conservator and the restorer.
- produce, fit and finish, using hand and machine tools, components for antique and older watches.
- undertake basic refurbishment of watch cases.

Unit 13, continued:-

Assessment Procedure:-

There are two aspects to the assessment of this unit:-

1. Internal Assessment:-

The candidate prepares a “Portfolio” detailing the work completed in the conservation / restoration of five watches. The internal assessment requires the completion of the standard documentation similar to that necessary for Units 9 and 10 “Record of Repairs”. There is a “**List of Contents**” available to guide the candidate when selecting items for the Portfolio and to enable a list of the watches to be recorded. A standard “**Mechanical Watch Form**” or “**Quartz Watch Form**” is used for each item to provide basic information about the piece and the work which has been undertaken.

Each watch is internally assessed by a qualified professional member of the British Horological Institute (MBHI / FBHI).

Any watch is suitable for inclusion in the Portfolio. It is, however, necessary to ensure that the work is not merely of a routine repair nature but requires more complex repair / replacement of components / conservation. As a guide the following is required in each instance:-

- a) The inclusion of “more complex repair techniques”
- b) The replacement of at least two significant components that require manufacture by the candidate

Examples of “more complex repair techniques”:-

- 1) *Train:-*
 - a) *bush worn pivot holes*
 - b) *use of depthing tool to check **and adjust** depths of wheels and pinions*
 - c) *re-pivot worn / broken pivots, including making a flat drill*
 - d) *correct end-shakes*
 - e) *damaged wheels and pinions (make and replacement teeth)*
 - f) *truing wheels*
- 2) *Balance and Escapement:-*
 - a) *Replace pallet jewels*
 - b) *Replace cylinder plugs*
 - c) *Replace impulse pin*
 - d) *Replace hairspring*

Examples of “significant components” to be replaced by the candidate, these components are to be actually made by the candidate not the fitting of purchased or modified components:-

- 1) *Escapement:-*
 - a) *Replace balance staff*
- 2) *Train:-*
 - a) *Replace damaged barrel / train wheel*
 - b) *Replace arbor and pinion*
- 3) *Various:-*
 - a) *Replace stem*
 - b) *Replace setting lever spring*
 - c) *Replace ratchet wheel*

2. External Verification / Assessment:-

Verification of the Portfolio:-

Each watch has already been internally assessed by qualified professional member of the British Horological Institute (MBHI / FBHI or equivalent approved by the Examinations Board). The “Portfolio” is checked by the BHI Senior Examiner to ensure that the required number of items has been conserved / restored, every item has been approved to indicate that the work was undertaken to a high standard and the nature of the work complies with the guidelines. The documentation, present in the handbook, “Specimen Papers - Certificate in the Repair, Restoration and Conservation of Clocks / Watches”, summarise the requirements and assist the verification process. (“List of Contents” for the Portfolio lists the conservation / restoration items; “Mechanical Watch Form” or “Quartz Watch Form” forms give basic documentation for each watch)

Assessment of the Supplementary Information in the Portfolio:-

The basic documentation required using the “Mechanical Watch Form” or “Quartz Watch Form” form is supplemented by the candidate with written material, sketches and / or photographs giving, for each item, details of :-

- a. Appraisal
- b. The Conservation / Restoration Process
- c. A Justification of the Conservation / Restoration Approach
- d. Research

Further guidance concerning this Supplementary Information is available in the Handbook providing examples of specimen papers

The Portfolio is initially checked and if found to meet the examination requirements a Pass is awarded. Any supplementary is then assessed by two Examiners who award marks for:-

- a. Depth of supplementary information
- b. Quality of content
- c. Use of photographs / drawings / sketches
- d. Approach to restoration / conservation

A candidate will be awarded a Pass with Merit if the Portfolio is of the required standard.

If the required number of items has not been presented, the forms are incomplete or the work does not conform to the guidelines, the Portfolio will be returned with a note of explanation.

A candidate may, on payment of the examination fee, resubmit a Portfolio which has been found to be “incomplete”.

Two grades of Pass are awarded Pass (40%) and Pass with Merit (66%).

The five watches may also be included in the Record of Repairs required for Unit 10, Final Grade, Part II : The Practical Repair of Watches.