國立中正大學

107 年度「鼓勵教師開發教材」申請表

申請日期：2018 年 05 月 11 日

<table>
<tr><td>教材名稱</td><td colspan="3">Feedback Dynamics Theory</td></tr>
<tr><td rowspan="5">適用科目
及科目屬性
（得自行增列）</td><td colspan="3">科目名稱： (中文) 迴授系統分析
(英文) Analysis of Feedback Systems</td></tr>
<tr><td>課程編號：4208752</td><td colspan="2">開課系所：機械工程所</td></tr>
<tr><td>學分數：3</td><td colspan="2">預估修課人數：30</td></tr>
<tr><td>□必修 ■選修</td><td colspan="2">□大學部 ■研究所</td></tr>
<tr><td colspan="3">■一般課程 □實習實驗課程 □數位學習課程
□其他類課程 □全程英語課程</td></tr>
<tr><td rowspan="3">教材開發教師
或教師群資料
（得自行增列）</td><td>姓名：洪博雄</td><td colspan="2">系所別：機械工程</td></tr>
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<tr><td colspan="3"></td></tr>
<tr><td rowspan="3">協助製作之教
學獎助生資料</td><td></td><td colspan="2"></td></tr>
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<tr><td colspan="3"></td></tr>
<tr><td>教材類別</td><td colspan="3">■一般書籍出版品 □數位教材（需為可以申請認證之數位教材）</td></tr>
<tr><td>本年度是否執
行深耕計畫其
他子計畫</td><td colspan="3">■否
□是 子計畫名稱：_____</td></tr>
<tr><td>教材開發
計畫</td><td colspan="3"><u>Preface to the Textbook</u>:

For a physical system under investigation, representation of the intrinsic coupling into feedback interconnection can usually help find the roots of its behaviors, and then we further design based thereon. Once the feedback is constructed, we can then take advantage of the special tools available for feedback systems that have been well developed in the field of control theory. Therefore feedback construction brings in new opportunities to scientific probes, which have made the theory of feedback dynamics a hot research topic over many years. The opportunity is exemplified by the fact that the feedback interconnection of two stable systems could be unstable, which make possible to find the principle of thermoacoustic propulsion and to prove the untruth of time-delay diffusion.
In this book are firstly functional representations of lumped and distributed dynamics revised. The theory of feedback construction of physical systems is presented in Part II. This theory is a fusion of Thevenin-Norton equivalence and</td></tr>
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	the virtual-source realization of boundary/initial inhomogeneity. Specially, the 'existence' of something is interpreted due to robustness of its feedback structure. Part III collects typical tools for analysis of feedback systems. These tools include root locus, Nyquist criterion, Circle criterion, Popov criterion, Small-gain theorem, and Large-gain theorem. Nyquist criterion can be extended for nonlinear dynamics by the introduction of the describing function of a nonlinear feedback. For memory-fee, nonlinear feedbacks, root locus becomes a powerful tool with the help of Dynamical Equilibrium. Based on the theory of passivity, Circle and Popov are also for memory-fee, nonlinear feedbacks. Small-gain and Large-gain theorems come from the dissipativity theory, which are for general dynamics, including nonlinear and distributed systems, but comparatively conservative. Part IV is to present several famous achievements with feedback dynamics theory, including the combustion instability suppression, thermoacoustic engines design, the finding of thermal inductance, and the investigation of boundary inhomogeneity in heat conduction. Table of Contents: It follows that this textbook includes the following contents: 1. Introductive Examples of feedback construction of physical systems 2. 1D transfer functions 3. 2D transfer functions 4. Delta function and its derivatives 5. The theory of realization: realization of boundary/initial inhomogeneity into virtual sources 6. The theory of equivalence: Thevenin and Norton equivalent circuits 7. Passivity and dissipativity, Circle criterion, Popov criterion, Small-gain theorem and Large-gain theorem 8. Nyquist criterions with describing functions 9. Root locus with Dynamical Equilibrium 10. Example 1: combustion instability 11. Example 2: self-excited thermoacoustic engines 12. Example 3: the finding of thermal inductance 13. Example 4: heat conduction Organization of the Textbook : Chapter 1: Introduction 1. Introductive example: Harmonic motion is the feedback interconnection of inertia and stiffness 2. Introductive example: Phase Lock Loop as real-time frequency-to-voltage transducer 3. Introductive example: van der Pol oscillators as frequency generator 4. Introductive example: Operational amplifier circuits- the conservation law 5. Introductive example: Vibration is the feedback connection of inertia and stiffness Chapter 2: Functional Representation of Dynamics 1. Geometric isomorphism 2. Delta functions in Hilbert space 3. 1D transfer function for lumped dynamics

	4. 2D transfer function for distributed dynamics Chapter 3: Virtual Source Principle 1. Realization of initial inhomogeneity into temporally delta sources 2. Realization of boundary inhomogeneity into spatially delta sources 3. Examples on lumped dynamics 4. Examples on heat-conduction dynamics 5. Examples on wave dynamics Chapter 4: General Thevenin/Norton principle 1. The origin of Thevenin/Norton principle 2. Examples on heat-conduction dynamics Chapter 5: Feedback Analysis 1. Root locus 2. Frequency response 3. Dynamical equilibrium principle (extended from Root Locus) 4. Describing functions (extended from Nyquist criterion) Chapter 6: Self-excited Vibration 1. Thermoacoustic engines 2. Combustion instability Chapter 7: Thermal Inertia 1. The finding of thermal inductance 2.Crop circles Chapter 8: Mathematical Background 1. Limit-cycle analysis 2. Complete bases in functional analyses 3. Frequency-domain analysis of nonlinear dynamics 4. Feedback-control purposed mechanisms Exemplary Exercises: 1. Analyze the van der Pol oscillation with Time Averaging and Feedback Realization. Comment on these two methods. 2. Explain with feedback realization how the phase lock loop (PLL) can play as a real-time frequency-to-voltage transducer. 3. Explain with feedback realization the following statement: harmonic motion results from the feedback interconnection of stiffness and inertia. 4. Perform feedback analysis of the inverting feedback in operational amplifier circuits for amplification of signal voltage, whereby derive the principle: the multiplication of DC-gain and bandwidth is conserved. 5. Consider the feedback loop with forward gain k_1 and feedback gain k_2. Derive the close-loop gain from the viewpoints of asymptotical behavior and Cauchy sequence. Comment on these two methods. What is the ill-posedness condition? What is its physical significance? 6. Explain what the general Thevenin/Norton principle is. 7. Consider the following two inhomogeneous ODE, $\mathcal{G}$: $\dot{x}+x=0$; $x(0)=1$, and $\mathcal{H}$: $\dot{x}+x=\delta$; $x(0)=0$, wherein δ is the Dirac function. (a) Do both have the same solution?

	(b) Is $\mathcal{G}$'s solution coincident to $\mathcal{H}$'s solution for $t \geq 0$? Why or why not? (c) If you take Laplace transforms on both, does the initial time $t = 0$ indicates $t = 0^-$ or $t = 0^+$? (d) What's the solution of $\dot{x} + x = \delta$; $x(0) = 1$? Exemplary Exam problems: Write the answers to the following questions as essays: 1. Explain with feedback realization how the phase lock loop (PLL) can play as a real-time frequency-to-voltage transducer. 2. Explain with feedback realization the following statement: harmonic motion results from the feedback interconnection of stiffness and inertia. 3. Consider the feedback loop with forward gain k_1 and feedback gain k_2. Derive the close-loop gain from the viewpoints of asymptotical behavior and Cauchy sequence. Comment on these two methods. What is the ill-posedness condition? What is its physical significance? 4. Explain the realization of initial conditions to virtual sources in the feedback construction. 5. Explain the realization of boundary inhomogeneity as virtual source. Core Training with this Textbook 1. Advanced knowledge in scientific investigation and engineering design with feedback dynamics theory 2. Plan and execution of development projects in scientific investigation and engineering design with feedback dynamics theory 3. Proficiency at professional writing in scientific investigation and engineering design with feedback dynamics theory 4. Capacity of innovative thinking and independent problem solving for scientific investigation and engineering design with feedback dynamics theory 5. Effectiveness in communication and coordination in multi-disciplinary environments 6. Well-balanced global vision 7. Capability of leadership, planning, and management 8. Engagement to lifelong learning

申請人簽章		單位主管簽章	
審查單位核章：			

國立中正大學

107 年度「鼓勵教師開發教材」自評表

教材名稱： Feedback Dynamics Theory　　教材類別： 教科書

教師姓名： 洪博雄　　學院系所： 工學院機械工程系

評分指標及比例	得分	說明
教材廣泛使用之可行性 （30 分）	30	此書是動力分析的教科書，亦為以下科目的必要參考書 1. 熱聲學 2. 燃燒不穩定 3. 熱慣性 4. 迴授系統分析與合成 5. 分佈參數系統 6. 嵌入式控制器設計 7. 熱聲動力與控制 8. 電動車動力與控制 9. 古典控制 10. 線性系統
教材之創新性 （20 分）	20	近幾年有很多科學新發現，以致工程新工法，乃仰賴迴授動力理論，但是目前全世界沒有迴授動力理論相關的教科書。因此，本書將散於各領域的相關研究，深入淺出，組織整理成一部教科書，用於教學與研究工具書。
符合系所發展特色 （20 分）	20	本教科書符合機械工程系所之教學發展特色，培養學生 1. 具備基本工程數學、固體力學、熱流力學、自動控制及材料科學分析的能力 2. 吸收與整合跨領域知識的能力 3. 執行固力實驗、熱流實驗、自動控制實驗、電子學實驗和分析數據的能力 4. 撰寫程式語言與電腦輔助設計的能力 5. 具備機械系統、元件設計與製程規劃的能力 6. 發掘、分析及解決專業問題的能力 7. 實作與創新的能力 8. 從事科技寫作和報告展演的能力 9. 具備團隊合作、有效溝通及計劃管理的能力 10. 學習通識、體現科技倫理與社會責任的能力

教材的完整性（提供學生評量及教師輔助資源等）（20 分）	20	本教科書具教材的完整性，並提供學生評量及教師輔助資源等。
其他特色（10 分）	10	本書的例題、習題與說明舉例，使用最新的相關研究。
總分	100	總言之，此教科書是工學院不可或缺的，有很多科學新發現，工程新工法，仰賴迴授動力理論，但是目前全世界沒有相關的教科書。也因此，本書的例題、習題與說明舉例，將取材於最新的相關研究。

※請依各指標自評，本自評表將列入教材開發審查依據之一。