

King Saud University
College of Engineering
Petroleum and Natural Gas Engineering Department



PGE 491

Petroleum and Natural Gas Economics

اقتصاديات البتروول و الغاز الطبيعي

Compiled by

Professor Musaed N. J. Al-Awad

أ.د. مساعد بن ناصر العواد

malawwad@ksu.edu.sa



March 2023 Version

TABLE OF CONTENTS

INTRODUCTION

- Table of Contents ... 1
- Course Learning Outcomes and Syllabus ... 2
- Brief on Worldwide Economy Systems ... 3

CHAPTER 1: HISTORY OF OIL IN SAUDI ARABIA

- 1.1 The Importance of Oil and Gas Resources in the Middle East ... 4
- 1.2 OPEC, USA, Rest of the World Oil Reserves, Production and Consumption ... 7
- 1.3 History of Oil Discovery in Saudi Arabia ... 8
- 1.4 Major Saudi Arabia Oil and Gas Fields ... 11
- 1.5 Saudi Arabia Oil Ministers ... 14
- 1.6 Giant Oil and Gas Fields ... 15
- 1.7 Saudi Arabia Oil and Gas Fields List ... 17
- 1.8 Saudi Arabia Geological Column ... 19
- 1.9 Crude Oil Classification and Refining ... 22
- 1.10 Carbon Net Zero Emission ... 24
- 1.11 Carbon Capture, Utilization And Storage (CCUS) ... 25
- 1.12 Saudi Arabia-Kuwait Neutral (Divided) Zone ... 25
- 1.13 Legal Boundaries of Waters and Airspace ... 26
- 1.14 Pollution Caused by Petroleum Operations ... 27

CHAPTER 2: THE INTERNATIONAL OIL INDUSTRY

- 2.1 National and International Oil Companies and OPEC ... 28
- 2.2 Oil and Gas Ownership Types ... 28
- 2.3 OPEC, OPEC+, OAPEC and IEA ... 28
- 2.4 Swing Produces, Inflation, Depletion, and Energy Sources ... 30
- 2.5 Unconventional Oil and Gas Resources ... 30
- 2.6 The Difference between Oil Shale, Shale Oil and Shale Gas? ... 31
- 2.7 Definition of Oil and Gas Reserves ... 32
- 2.8 Depletion and Depreciation ... 34

CHAPTER 3: OIL PRICES HISTORY AND PRICING CRITERION

- 3.1 Oil Pricing History ... 35
- 3.2 Oil Pricing Criterion ... 37
- 3.3 OPEC Reference Basket (ORB) Price ... 39
- 3.4 Oil Paper and Wet Barrels ... 39
- 3.5 The Port of Rotterdam ... 39
- 3.6 Law of Supply and Demand ... 40
- 3.7 Law of Oil Equilibrium (Bottom) Price ... 40

CHAPTER 4: BASICS OF ENGINEERING ECONOMY

- 4.1 Engineering Economy ... 42
- 4.2 Key Factors For Successful Project ... 42
- 4.3 Investment and Economic Limit ... 43
- 4.4 Capital Expenditure (CAPEX) and Operating Expenditure (OPEX) ... 43
- 4.5 Petroleum Field Exploitation Cost Analysis ... 44
- 4.6 Nominal and Effective Interest Rates ... 44
- 4.7 Complex Interest Rate ... 45
- 4.8 Horizontal Time-Fund Flow Diagram ... 46
- 4.9 Formulas for Continuous and Lump Sum Flow of Fund ... 47
- 4.10 Mutually Exclusives Selection Methods and Decision Strategy ... 47
- 4.11 Decision Screening Yardsticks for Economical Projects ... 47
 - 4.11.1 Net Present Value (NPV) ... 48
 - 4.11.2 Minimum Rate of Return (ROR) ... 49
 - 4.11.3 Payout (Payback) Period (POT) ... 52
 - 4.11.4 Profit-to-Investment Ratio (Profitability Index, P/I) ... 54
- 4.12 Summary of Economical Screening Yardsticks ... 56

CHAPTER 5: FIELD EXAMPLES BASED ON OIL PRODUCTION DATA

- 5.1 Field Examples Based On Oil Production Data ... 57

CHAPTER 6: RISK, UNCERTAINTY, ETHICS, ENVIRONMENTAL IMPACTS, AND PEAK OIL THEORY

- 6.1 Oil and Gas Industry Sectors ... 59
- 6.2 Potential Environmental Impacts of Oil and Gas Activities ... 59
- 6.3 Risk and Uncertainty in the Oil and Natural Gas Industry ... 60
- 6.4 Oil Price Elasticity ... 61
- 6.5 Peak Oil Theory ... 62
- 6.6 SPE Ethics and Professional Responsibility ... 63

PGE 491: PETROLEUM AND NATURAL GAS ECONOMICS, 2(2-1-0)

INSTRUCTOR	Professor Musaed N. J. AlAwad
OFFERING:	Required and offered every semester
YEAR/LEVEL:	5/9
PRE-REQUISITES:	None
CO-REQUISITES:	PGE 496
TEXT BOOK	Handouts prepared by the course instructor
REFERENCES:	<ul style="list-style-type: none">• Franklin J. S.: "Economic Evaluation and Investment Decision Methods.", ISBN-13: 978-1878740137, 802 pages, 14th Edition (March 1, 2014).• Thompson & Wright: "Oil Property Evaluation". Anthony J. Tarquin: "Engineering Economy", McGraw-Hill Inc., 1976.• OPEC, OAPEC, IEA and DOE web-sites information.• سيد فتحي أحمد الخولي: "اقتصاديات البترول"، مكتبة دار حافظ للنشر والتوزيع، جدة، المملكة العربية السعودية.• عبدالعزيز بن لعبون: "صناعة النفط في عهد خادم الحرمين الشريفين الملك فهد بن عبدالعزيز"، جامعة الملك سعود.

EVALUATION PLAN Home Works (10%), Mid-term exam 1 (25%), Mid-term exam 2 (25%), Final Exam (40%).

TOPICS COVERED Brief on Islamic Economy Principles, The Importance of Oil and Gas Resources in the Middle East, OPEC, USA, Rest of the World Oil Reserves, Production and Consumption, History of Oil Discovery in Saudi Arabia, Major Saudi Arabia Oil and Gas Fields, Saudi Arabia Oil and Gas Fields List, Saudi Arabia Oil Ministers, Worldwide giant oil and gas fields, Saudi Arabia Geological Column, Crude Oil Classification, Carbon Emission, Carbon Capture, Utilization And Storage (CCUS), Saudi Arabia-Kuwait Neutral (Divided) Zone, Legal Boundaries of Waters and Airspace, Oil and Gas Ownership Types, National and International Oil Companies and OPEC, OPEC, OPEC+, OAPEC and IEA, Swing Produces, Inflation, Depletion, and Energy Sources, Unconventional Oil and Gas Resources, The Difference between Oil Shale, Shale Oil and Shale Gas, Definition of Oil and Gas Reserves, Depletion and Depreciation, Oil Pricing History, Oil Pricing Criterion, OPEC Reference Basket (ORB) Price, Oil Paper and Wet Barrels, Law of Supply and Demand, Law of Oil Equilibrium (Bottom) Price, Engineering Economy, Key Factors For Successful Project, Investment and Economic Limit, Capital Expenditure (CAPEX) and Operating Expenditure (OPEX), Salvage Value (S), Nominal and Effective Interest Rates, Complex Interest Rate, Petroleum Field Exploitation Cost Analysis, Horizontal Time Line Diagram, Formulas for Continuous and Lump Sum Flow of Fund, Mutually Exclusives Selections and Decision Methods, Decision Screening Yardsticks for Economical Projects, Net Present Value (NPV), Minimum Rate of Return (ROR), Payout (Payback) Period (POT), Profit-to-Investment Ratio (Profitability Index, P/I), Field Examples Based On Oil Production Data, Oil and Gas Industry Sectors, Potential Environmental Impacts of Oil and Gas Activities, Risk and Uncertainty in the Oil and Natural Gas Industry, Oil Price Elasticity, Peak Oil Theory, SPE Ethics and Professional Responsibility.

RELATED ABET STUDENTS OUTCOMES (SOs) and NCAAA LEARNING DOMAINS (LDs):

- ❖ **NCAAA-K1:** An ability to gain knowledge of mathematics, basic sciences, general engineering, Islamic values and Arabic literature.
- ❖ **ABET-SO1 (NCAAA-S1):** An ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics.
- ❖ **ABET-SO4 (NCAAA-C1):** An ability to recognize ethical and professional responsibilities in engineering situations and make informed judgments, which must consider the impact of engineering solutions in global, economic, environmental, and societal contexts.

MAIN COURSE CLOs RELATION TO PROGRAM (ABET) SOs:

CLO1: SO1	SO1 = 100%
An ability to recognize knowledge of basic oil and gas industry economical terms and related international organizations.	An ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics.
CLO2: SO1	SO1 = 100%
An ability to evaluate petroleum engineering projects using economic decision yardsticks and make decision among alternatives with consideration of its impact on national and international economics.	An ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics.
CLO3: SO4	SO4 = 100%
An ability to recognize ethical and professional responsibilities in engineering situations and make informed judgments, which must consider the impact of engineering solutions in global, economic, environmental, Risk and Uncertainty.	An ability to recognize ethical and professional responsibilities in engineering situations and make informed judgments, which must consider the impact of engineering solutions in global, economic, environmental, and societal contexts.

**KING SAUD UNIVERSITY
COLLEGE OF ENGINEERING
PETROLEUM AND NATURAL GAS ENGINEERING DEPARTMENT
PGE 491**

**Petroleum and Natural Gas Economics
Professor Musaed N. J. AlAwad
Tutorial # 1: History of Oil in Saudi Arabia**

1. Discuss the importance of the Middle East (Arabian Geological Plate) oil and gas resources.
2. Discuss reserves, production, and consumption rates of USA, OPEC, and the rest of the World.
3. Outline the history of oil discovery in Saudi Arabia.
4. What is the total proven oil reserve and the total proven gas reserves in Saudi Arabia?
5. What is the current daily oil production of Saudi Arabia?
6. Discuss the main types of crude oil in terms of name, API, and example fields.
7. What is the classification of the following crude oils: 0.88 g/cc, 7.8 ppg, 61.3 pcf?
8. List the names of the major Saudi oil fields and two gas fields.
9. Discuss the Saudi geological column in terms of oil reserves percentage.
10. What are the main types of sedimentary rocks in which the main Middle East of oil and gas reservoir are located? What are their shares percentage?
11. What are the share percentages of the Middle East in the World oil and gas reserves and production?
12. Discuss the share of medium, giant, and super giant oil fields in the World total production.
13. Compare between OPEC, USA and the rest of the World in terms of oil reserves, production and consumption.
14. What are the main sources of carbon emission? Explain how captured carbon can be stored and utilized.
15. What is the meaning of Carbon Net Zero Emission? Why is it important? How we can stop climate change?
16. Write a brief on Saudi Arabia-Kuwait divided (neutral) zone. Why Kuwait and KSA demand the division of the common area between them?
17. What are the main processes may cause pollution to the environment?

**KING SAUD UNIVERSITY
COLLEGE OF ENGINEERING
PETROLEUM AND NATURAL GAS ENGINEERING DEPARTMENT
PGE 491**

Petroleum and Natural Gas Economics

Professor Musaed N. J. AlAwad

Tutorial # 2: The International Oil Industry

1. List the main national oil companies, international oil companies, and service companies operating in Saudi Arabia.
2. What are the main types of oil and gas ownerships? Which one is applicable in Saudi Arabia?
3. Does the type of oil ownership matter?
4. What are the main types of pollution caused by petroleum operations?
5. Write a detailed essay on OPEC including its establishment, founding members, current members, head quarter, oil basket price, etc.
6. Write a detailed essay on OPEC+ alliance.
7. Define: Swing producer, OPEC, IEA, Inflation, Salvage value, and depletion.
8. Define conventional hydrocarbon resources, and then mention at least 5 unconventional resources for oil and 4 unconventional resources for natural gas.
9. Discuss the SPE definition for oil and gas reserves?
10. Discuss the EIA definition for oil and gas reserves?
11. What is the difference between oil shale, shale oil?
12. What are the main consequences of unconventional hydrocarbon production?

**KING SAUD UNIVERSITY
COLLEGE OF ENGINEERING
PETROLEUM AND NATURAL GAS ENGINEERING DEPARTMENT
PGE 491**

**Petroleum and Natural Gas Economics
Professor Musaed N. J. AlAwad
Tutorial # 3: The International Oil Industry**

1. Define physical depreciation and functional depreciation.
2. List the top ten factors that affect the price stability of crude oil.
3. Mention the four main properties of crude oil which control quality and price.
4. Discuss the World crude oil markers in terms of its name, geographic Location, properties, and exchange market.
5. Write the formula used for crude oil pricing and precisely define its terms.
6. Define OPEC reference basket (ORB) price.
7. Define market clearing price. Use schematic diagrams to clarify your answer.
8. Discuss oil price history in terms of shocks occurred.
9. Define crude oil dry and wet oil barrels.
10. Discuss the law of supply and demand in terms of data required and how it is collected, market clearing price, shortage and surplus in supply. You should use schematic diagrams to clarify your answer.
11. Discuss the oil equilibrium (bottom) price law.

KING SAUD UNIVERSITY
COLLEGE OF ENGINEERING
PETROLEUM AND NATURAL GAS ENGINEERING DEPARTMENT
PGE 491

Petroleum and Natural Gas Economics

Professor Musaed N. J. AlAwad

Tutorial # 4: Basics of Engineering Economy

1. Define: Engineering Economics, Investment, Economic Limit, Capital Expenditure (CAPEX), Operating Expenditure (OPEX), and Salvage value.
2. Discuss the main essential factors (skills) required for successful projects.
3. What is Gantt chart?
4. Define nominal interest rate and effective interest rate.
5. What is the mathematical relationship between the nominal interest rate and the effective interest rate?
6. What is the effective annual interest rate if the nominal interest rate is 10% compounded continuously, daily, weekly, monthly, quarterly, semi-annually, and annually? Plot your answers for verification.
7. Define complex interest rate.
8. A customer planning to buy a house at \$500,000. A bank is agreed to give him a loan of \$500,000 at a complex interest rate of 10%/year over a period of 5 years. It is required to calculate:
 - The total amount to be paid for the bank.
 - The amount of the annual payments for the bank?
 - Bank total profit?
9. Repeat question 6 if the bank interest rate is changed to 10%/quarter.
10. Repeat question 6 if the customer will pay to the bank \$100,000 in advance.
11. Define mutually exclusives selections and give examples.
12. Sketch the flow chart of investment decision making strategy.
13. List the main decision screening yardsticks for economical projects.
14. Explain how profitable projects are selected using “Decision Making Strategy”
15. Define NPV, what is the decision criterion for NPV. Write down the NPV generalized formula.

**KING SAUD UNIVERSITY
COLLEGE OF ENGINEERING
PETROLEUM AND NATURAL GAS ENGINEERING DEPARTMENT
PGE 491**

Petroleum and Natural Gas Economics

Professor Musaed N. J. AlAwad

Tutorial # 5: Net Present Value

1. Given that $i^* = 9\%$ /year and inflation $i_d = 10\%$ /year, compute Net Present Value (NPV) for the following project, then write down your investment decision:

Stage	Year	Investment, KSAR	Continuous Income, kSAR
Development	0	0	0
	1	4000	0
	2	4000	0
	3	2000	0
Operation	4	0	3400
	5	0	3400
	6	0	3400
	7	0	3400
	8	0	3400

2. Given that $i^* = 11\%$ /year and inflation $i_d = 8\%$ /year, compute Net Present Value (NPV) for the following project, then write down your investment decision:

Stage	Year	Investment, KSAR	Continuous Income, kSAR
Development	0	0	0
	1	4000	0
	2	3000	0
	3	3000	0
Operation	4	0	1000
	5	0	5000
	6	0	6000
	7	2000	4000
	8	0	2000

3. Given that $i^* = 15\%$ /year and inflation $i_d = 10\%$ /year, compute Net Present Value (NPV) for the following project, then write down your investment decision:

Stage	Year	Investment, MSAR		Continuous Income, MSAR
		Capex	Opex	
Development	0	0	0	0
	1	10	0	0
	2	10	0	0
	3	10	0	0
Operation	4	0	2	20
	5	0	2	30
	6	0	2	40
	7	0	2	50

4. Given that $i^* = 20\%$ /year and inflation $i_d = 11\%$ /year, compute Net Present Value (NPV) for the following project, then write down your investment decision:

Stage	Year	Investment, KSAR	Continuous Income, kSAR
Development	0	10000	0
Operation	1	0	1000
	2	0	5000
	3	0	6000
	4	0	4000
	5	0	2000

**KING SAUD UNIVERSITY
COLLEGE OF ENGINEERING
PETROLEUM AND NATURAL GAS ENGINEERING DEPARTMENT
PGE 491**

Petroleum and Natural Gas Economics

Professor Musaed N. J. AlAwad

Tutorial # 6: Minimum Rate of Return

1. Define rate of return (ROR). What is the criterion used in ROR analysis?
2. Prove that when investment duration is equal to infinity ($n=\infty$), the rate of return is given by:

$$i = \left(\frac{A_c}{I} \right) = \text{ROR}$$

3. Prove when the initial investment is equal to the salvage value ($I=S$):, the rate of return is given by:

$$i = \left(\frac{A_c}{I} \right) = \text{ROR}$$

4. Would you invest in the following project based on rate of return value (ROR) economic evaluation tool if the bank interest rate $i^* = 9\%$ /year, inflation $i_d = 11\%$ /year and Salvage value = zero?

Stage	Year	Investment, KSAR	Continuous Income, kSAR
Development	0	0	0
	1	4000	0
	2	4000	0
	3	2000	0
Operation	4	0	3400
	5	0	3400
	6	0	3400
	7	0	3400
	8	0	3400

5. Would you invest in the following project based on rate of return value (ROR) economic evaluation tool if the bank interest rate $i^* = 10\%$ /year, inflation $i_d = 17\%$ /year and Salvage value = 10000 KSAR?

Stage	Year	Investment, KSAR	Continuous Income, kSAR
Operation	0	10000	0
	1	0	2500
	2	0	2500
	3	0	2500
	4	0	2500
	5	0	2500

6. Would you invest in the following project based on rate of return value (ROR) economic evaluation tool if the bank interest rate $i^* = 15\%$ /year, inflation $i_d = 7\%$ /year and Salvage value = 6000 KSAR?

Stage	Year	Investment, KSAR	Continuous Income, kSAR
Development	0	5000	0
	1	5000	3000
Operation	2	0	3000
	4	0	3000
	5	0	3000

**KING SAUD UNIVERSITY
COLLEGE OF ENGINEERING
PETROLEUM AND NATURAL GAS ENGINEERING DEPARTMENT
PGE 491**

**Petroleum and Natural Gas Economics
Professor Musaed N. J. AlAwad
Tutorial # 7: Payback (Payout) Time**

1. Define payout time (POT). What is the POT range for typical projects?
2. Write the general POT formula and draw the general plot for typical projects.
3. Why most investors are looking for minimum POT?
4. Compute the undiscounted payout time of the following project (Salvage value= 3000 kSAR):

Stage	Year	Investment, KSAR	Continuous Income, kSAR
Development	0	0	0
	1	4000	0
	2	4000	0
	3	2000	0
Operation	4	0	3400
	5	0	3400
	6	0	3400
	7	0	3400
	8	0	3400

5. Compute the undiscounted payout time of the following project:

Stage	Year	Investment, KSAR	Continuous Income, kSAR
Development	0	0	0
	1	4000	0
	2	3000	0
	3	3000	0
Operation	4	0	1000
	5	0	5000
	6	0	6000
	7	0	4000
	8	0	2000

6. Compute the undiscounted payout time of the following project:

Stage	Year	Investment, KSAR	Continuous Income, kSAR
Development	0	0	0
	1	4000	0
	2	3000	0
	3	3000	0
Operation	4	0	1000
	5	0	5000
	6	0	6000
	7	2000	4000
	8	0	2000

7. Compute the undiscounted payout time of the following project:

Stage	Year	Investment, kSAR	Continuous Income, kSAR
Development	0	0	0
	1	6000	0
	2	5000	0
	3	5000	0
Operation	4	0	5000
	5	0	4000
	6	0	9000
	7	1000	2000
	8	0	4000
	9	0	2000
	10	1000	2000
	11	0	3000

8. Compute the undiscounted payout time of the following project:

Stage	Year	Investment, MSAR		Continuous Income, MSAR
		Capex	Opex	
Development	0	0	0	0
	1	10	0	0
	2	10	0	0
	3	10	0	0
Operation	4	0	2	20
	5	0	2	30
	6	0	2	40
	7	0	2	50

9. Compute the discounted and the undiscounted payout times of the following project if the discounting factor is equal to 10%/year.

Stage	Year	Investment, KSAR	Continuous Income, kSAR
Development	0	10000	0
Operation	1	0	1000
	2	0	5000
	3	0	6000
	4	0	4000
	5	0	2000

10. Compute the discounted and the undiscounted payout times of the following project if the discounting factor is equal to 10%/year.

Stage	Year	Investment, KSAR	Continuous Income, kSAR
Development	0	0	0
	1	5000	0
	2	5000	0
Operation	3	0	1000
	4	0	5000
	5	0	6000
	6	0	4000
	7	0	2000

**KING SAUD UNIVERSITY
COLLEGE OF ENGINEERING
PETROLEUM AND NATURAL GAS ENGINEERING DEPARTMENT
PGE 491**

Petroleum and Natural Gas Economics

Professor Musaed N. J. AlAwad

Tutorial # 8: Profit-to-Investment Ratio

1. Define profit-to investment ratio (P/I).
2. What is the general formula for P/I calculations?
3. What is the decision criterion for P/I?
4. If P/I for a specific project is equal to 1.5, what does it mean?
5. Neglecting inflation, compute the profit-to-investment (P/I) value and make your decision for the following project:

Stage	Year	Investment, KSAR	Continuous Income, kSAR
Development	0	0	0
	1	4000	0
	2	4000	0
	3	2000	0
Operation	4	0	3400
	5	0	3400
	6	0	3400
	7	0	3400
	8	0	3400

6. Neglecting inflation, compute the profit-to-investment (P/I) value and make your decision for the following project:

Stage	Year	Investment, kSAR	Continuous Income, kSAR
Development	0	0	0
	1	6000	0
	2	5000	0
	3	5000	0
Operation	4	0	5000
	5	0	4000
	6	0	9000
	7	4000	2000
	8	0	4000
	9	0	2000
	10	2000	2000
	11	0	3000

7. Knowing that inflation is equal to 8%/year, compute the undiscounted and discounted profit-to-investment (P/I) value and make your decision for the following project:

Stage	Year	Investment, KSAR	Continuous Income, kSAR
Development	0	0	0
	1	4000	0
	2	3000	0
	3	3000	0
Operation	4	0	1000
	5	0	5000
	6	0	6000
	7	2000	4000
	8	0	2000

**KING SAUD UNIVERSITY
COLLEGE OF ENGINEERING
PETROLEUM AND NATURAL GAS ENGINEERING DEPARTMENT
PGE 491**

Petroleum and Natural Gas Economics

Professor Musaed N. J. AlAwad

Tutorial # 9: Real Field Examples

1. The following table is a historical oil production, oil prices, and operating costs in Saudi Arabia. It is required to calculate the NPV before the start of this project in 1965 if the inflation rate was constant at 7%/year and the salvage value is zero.

Period, Year		Capex, MMM\$	Production, bbl/day	Oil Price, \$/bbl	Opex, \$/bbl	
Development Stage	0	1965	0	0	-	0
	1	1966	1	0	-	0
	2	1967	10	0	-	0
	3	1968	10	0	-	0
	4	1969	5	0	-	0
Opration Stage	5	1970	0	3548865	2.0	0.5
	6	1971	0	4497576	2.0	0.5
	7	1972	0	5723395	2.0	0.5
	8	1973	0	7334647	4.0	1.0
	9	1974	0	8209706	8.0	1.0
	10	1975	0	6826942	8.0	1.2
	11	1976	0	8343953	12.0	1.6
	12	1977	0	9016952	12.0	1.6
	13	1978	0	8066105	12.0	1.6
	14	1979	0	9251079	28.0	2.5
	15	1980	0	9631366	32.0	3.0
	16	1981	0	9623828	32.0	3.0
	17	1982	0	6327220	32.0	3.0
	18	1983	0	4374942	32.0	3.0
	19	1984	0	3922079	28.0	2.0
	20	1985	0	3041104	24.0	2.0
	21	1986	0	4689800	18.0	1.5
	22	1987	0	3991000	18.0	1.5
	23	1988	0	4928100	18.0	1.5
	24	1989	0	4840200	17.0	1.5
	25	1990	0	6351300	23.0	1.7
	26	1991	0	8300000	19.0	1.7
	27	1992	0	8000000	17.0	1.75
	28	1993	0	8000000	16.0	1.8
	29	1994	0	8000000	15.0	1.9
	30	1995	0	8000000	16.0	1.95
	31	1996	0	8000000	18.0	1.95

2. For the following petroleum project, it is required to calculate the NET PRESENT VALUE of the cash flow if the inflation rate is equal to 10%/year and the salvage value is zero.

Period, Year		Capex, MMM\$	Production, MMbbl/day	Oil Price, \$/bbl	Opex, \$/bbl	
Development Stage	0	1988	0	0	-	0
	1	1989	30	0	-	0
	2	1990	350	0	-	0
Opration Stage	5	1991	120	8	20	2.5
	6	1992	0	8	25	2.5
	7	1993	0	9	25	2.5
	8	1994	0	9	25	2.5
	9	1995	0	10	30	2.5
	10	1996	0	10	30	2.5
	11	1997	0	9	40	2.5
	12	1998	0	9	40	2.5
	13	1999	0	10	50	2.5
	14	2000	0	10	50	2.5
	15	2001	0	8	55	2.5
16	2002	0	8	55	2.5	

3. Using the following data, it is required to use NPV analysis to compare between vertical and horizontal oil wells profitability for one operation (production) year.

Oil viscosity = 3.5 cp, Oil price = 35 \$/bbl, Inflation rate (discounting factor) = 9%/year

Oil formation volume factor (β_o) = 1.1 bbl/STB, Wellbore diameter = 5.0 inch

Average reservoir pressure = 3382 psi, Wellbore pressure = 1142 psi

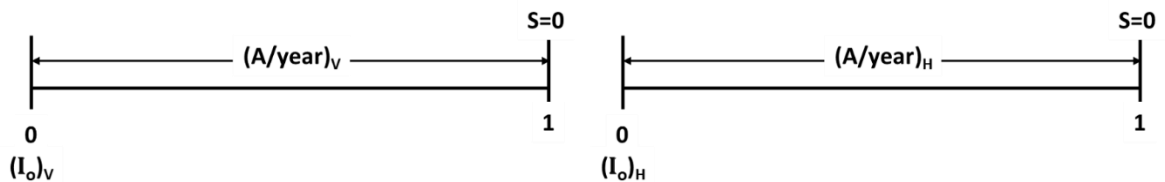
Reservoir thickness = 22 ft, Reservoir average permeability = 0.236 Darcy,

Drainage area = 139 acres, Horizontal section of the horizontal well = 1000 ft

Operating cost = 5 \$/bbl,

Vertical well drilling and completion cost (at the end of year 1) = MM\$1.5

Horizontal well drilling and completion cost (at the end of year 1) = MM\$3.5



$$q_v = \frac{7.081 k h \Delta P}{\beta_o \mu \ln\left(\frac{r_e}{r_w}\right)}$$

$$q_h = \frac{7.081 k h \Delta P}{\beta_o \mu \ln\left[\frac{1 + \sqrt{1 + \left(\frac{L}{2r_d}\right)^2}}{\left(\frac{L}{2r_d}\right)} + \left(\frac{h}{L}\right) \ln\left(\frac{h}{2\pi r_w}\right)\right]}$$

**KING SAUD UNIVERSITY
COLLEGE OF ENGINEERING
PETROLEUM AND NATURAL GAS ENGINEERING DEPARTMENT
PGE 491**

Petroleum and Natural Gas Economics

Professor Musaed N. J. AlAwad

Tutorial # 10: Risk, Uncertainty, and Ethics

1. Define the following terms:

- Upstream oil industry
- Midstream oil industry
- Downstream oil industry
- Risk
- Opportunity
- Threat
- Uncertainty
- Oil price elasticity, and inelasticity. Which one of them is oil price follows?

2. Using market supply and demand surveys shown below, it is required to determine the type of price elasticity of supply.

Price, \$	Supply #1, Boxes	Supply #2, Boxes
1	1.5	1.5
2	1.8	3.5
3	2.1	5.5
4	2.1	7.5
5	2.7	9.5

3. What is the impact of petroleum exploration and production industry activities on the environment?
4. Discuss the technical, economical and political risks involved in the petroleum exploration and production industry.
5. Write down the general equation used for price elasticity of supply (Pre) and define its terms.
6. Using schematic diagram, outline price elasticity change for: oil & gas, subsidized goods, monopoly, and other goods.
7. Briefly discuss the peak oil theory. Why its forecasts failed several times since 1974?
8. Define the term ethics? Then outline SPE code of conduct for professional actions and behavior.