JPMorganChase Women in Quantitative Finance Mentorship Program – 2025

Advanced assignment for Fixed Income

(Share your answers in a word doc with the question number and the answer) e.g.:

1. Answer1
2. Answer2
3. Answer3…

Questions

1. The distinction between investment-grade debt (BBB-or higher rated) and non-investment grade debt is best described by differences in:
    a. Tax status
    b. Credit quality
    c. Maturity dates
    d. Bond seniority

2. For this and the next 2 questions, consider the following bond: zero-coupon bond with notional $100, current price of $86 and time to maturity of 7 years. What is its yield-to-maturity?
3. What is its Macaulay duration?
4. What is its modified duration?
5. For this and the next 2 questions, consider the following bond: 5% coupon bond with notional $100, current price of $90 and time to maturity of 3 years. What is its yield-to-maturity?
6. What is its Macaulay duration?
7. What is its modified duration?
8. What is the current price of a 5% coupon bond with notional $100 and time to maturity of 30 years if its yield-to-maturity is 5%?
9. Rank the following bonds in terms of Macaulay duration:
    1. Zero coupon bond, notional $100, yield 6%, maturity 5 years
    2. 5% coupon bond, notional $100, yield 6%, maturity 5 years
    3. 7% coupon bond, notional $100, yield 6%, maturity 5 years
    4. 6% coupon bond, notional $100, yield 6%, maturity 4 years
10. True/False: Bonds with higher amortization have longer duration compared to bonds with lower amortization, all other characteristics (maturity, notional, etc.) being equal.
11. If we construct a yield curve based on yields of treasury bonds and another yield curve based on yields of corporate bonds of Apple, what can you say about the relation between these two curves?
12. Read about spot, par and forward curves. Assuming spot curve is upward sloping, will par and forward curves lie above or below the spot curve?
13. Read about what the yield curve shape says about the economy. In your own words describe any one theory as to why the yield curve is normally upward sloping. What is the shape of the yield curve today?

14. Read about credit spreads / yield spreads. What would you expect the relationship to be between yield spread and credit rating of a bond? Why?

ANSWERS

Answer 1-

The main difference between investment-grade bonds (BBB- and higher) and non-investment-grade bonds (BB+ and lower) comes down to credit quality. Investment-grade bonds are seen as safer because the chances of the issuer repaying their debt are high. On the other hand, non-investment-grade bonds (also called junk bonds) are riskier, so they offer higher interest rates to attract investors. Credit rating agencies like Moody's, S&P, and Fitch give bonds a rating based on the risk of the issuer defaulting (not paying back the money).

- Investment-grade bonds (AAA to BBB-) → Lower risk, lower interest rates.
- Non-investment-grade bonds (BB+ and lower) → Higher risk, higher interest rates.

Analysis of Other Options :

Tax Status is about whether a bond's interest income is taxable or tax-free. But tax status depends on who issues the bond (like government vs. corporate bonds), not on its rating. Both investment-grade and junk bonds can be either taxable or tax-free.

Maturity is just how long before the bond expires and the investor gets their money back. But a bond's rating isn't based on how long it lasts—both short-term and long-term bonds can be either investment-grade or junk.

Seniority refers to who gets paid first if a company goes bankrupt. But a senior bond can still be junk-rated, and a junior bond can still be investment-grade. So, while senior bonds are generally safer, seniority doesn't directly determine credit rating.

So, the correct answer is:
b) **Credit Quality**

Answer 2 to 4-

A zero-coupon bond is a bond that does not pay periodic interest (coupons). Instead, it is issued at a discount to its face value or notional value, and the investor receives the full face value at maturity. Formula for zero-coupon bond price:

P= F/((1+YTM)^T)

Where:

- P = Current bond price
- F = Face value (notional amount)
- YTM= Yield to Maturity (rate of return)
- T = Time to maturity (years)

Since a zero-coupon bond doesn't pay interest, the only return the investor gets comes from the difference between the purchase price and the face value.

2. **Yield-to-Maturity**

Solving the equation above we get-

YTM= (F/P)^(1/T) - 1

Given:

- Notional (Face Value) = 100
- Current Price (P) = 86
- Time to Maturity (T) = 7 years

YTM=(100/86)^(1/7)-1= 2.18 %

3. Macaulay Duration

For a zero-coupon bond, the Macaulay Duration is simply equal to the bond's time to maturity because all the cash flows (interest + principal) come at the very end.

Macaulay Duration = 7 years

4. Modified Duration

Modified duration estimates the percentage change in bond price for a 1% change in interest rates.

Modified Duration=Macaulay Duration/(1+YTM)= 6.8506

Answer 5 to 7-

Given:

Face/notional value: F = $100,

Current Price: $90

Coupon = 5% of $100= $5 per year

Time to maturity = 3 (in years)

5. Yield-to-Maturity

YTM(r) is interest rate that satisfies:

90 = 5/(1+r)^1+ 5/(1+r)^2+ 105/(1+r)^3

18r^3+ 53r^3 + 51r-5 =0

r= 0.08987

r= 8.987%= ~ 9%

So, YTM = 9%

6. Macaulay Duration

The Macaulay duration is the weighted average time of the cash flows, using the present value of each payment:

Duration=($\sum$ t · Ct/(1+y)t) / Price

C1= 5, C2=5, C3= 105

y= YTM= 0.09

P= 90

Sum of weighted present values- 1 · 5/(1.09)^1+ 2 · 5/(1.09)^2+ 3 · 105/(1.09)^3 = 256.241

Duration = 256.241/ 90 = 2.847

So, **Macaulay Duration= 2.85 yrs**

7. Modified Duration

Modified Duration=Macaulay Duration/(1+YTM)

= 2.85/1.09= 2.61

So, **Modified Duration= 2.61 yrs**

Answer 8-

Given:

Face/notional value : F = $100,

Time to maturity = 30 (in years)

Yield to maturity = 5% annually

Assuming coupons are paid annually : price of coupon = 5% of notional value

Annual coupon payment: C = 5% of $100 = $ 5(every year for 30 years)

Discounting to calculate bond price = $\sum_{t=1}^{T}$ C/(1+r)^t + F /(1+r)^T

Where C =$5 , r = YTM = 0.05, T =30

Calculating : P = C*(1-(1+r)^-30)/r +F/(1+r)^30 (substituting sum of gp)

P = 5*(1-(1.05)^-30)/0.05 + 100 /1.05^30 = 100

Therefore, current price of bond = $100
(this could also be deduced as coupon rate = YTM => bond price = face value)

Answer 9-

macaulay duration formula (assuming equal amount of coupons paid annually) :

$$\frac{\sum_{t=1}^{T} t \times C \,/\, (1+r)\text{^}t + T \times F \,/\, (1+r)\text{^}T}{\sum_{t=1}^{T} C \,/\, (1+r)\text{^}t + F \,/\, (1+r)\text{^}T}$$

1.Zero coupon bond, notional $100, yield 6%, maturity 5 years

Macaulay Duration = maturity for zero coupon bonds

therefore, macaulay duration = 5

2. 5% coupon bond, notional $100, yield 6%, maturity 5 years

Macaulay Duration = 4.534(substituting the values in the above formula)

intuitively: Lower coupon⇒ pays more later ⇒ higher duration than 7% bond (same maturity of 5 years)

3. 7% coupon bond, notional $100, yield 6%, maturity 5 years

Macaulay Duration = 4.4(substituting the values in the above formula)

4. 6% coupon bond, notional $100, yield 6%, maturity 4 years

Macaulay Duration = 2.497 (substituting the values in the above formula)

intuitively: Shorter maturity lowers duration significantly

Therefore , order is - **1) Zero-coupon bond (5 yrs) > 2) 5% coupon (5 yrs) > 3) 7% coupon (5 yrs)> 4) 6% coupon (4 yrs)**

Answer 10-

FALSE

When a bond amortizes, it pays back part of the principal along with each coupon payment. So with higher amortization, more of the total value is returned earlier.

Duration is the weighted average time to receive the bond's cash flows.
So, if cash flows come **earlier** that is higher amortization, the **duration becomes shorter** if all other characteristics like maturity, notional value remain the same.

In contrast, a bond with **low or no amortization** (like a bullet bond) gives you most of your money **at the end**, so the average wait time is longer — and that means **higher duration**.

Answer 11-

When comparing treasury bonds and corporate bonds, we have to be mindful of things like-

Treasuries are issued by governments and are considered mostly risk free or close to it, government is considered the safest borrower as it is extremely unlikely to default.

On the other hand, corporate bonds are generally associated with some level of credit risk- even if it's a well-established, financially solid and less likely to default big company like Apple.

So at any maturity , typically Apple should provide a higher yield than treasury bonds.

Hence, Apple's yield curve will be **shifted slightly upward** (higher yield at any time) compared to the Treasury curve as there exists a chance of risk considering the fact that Apple is still a company.

But mostly both will have similar yield curves as the risk is almost similar in a financially solid company like Apple and in government treasury bonds(considered to be almost risk free).

Answer 12-

Sources – investopedia.com, analystprep.com, Capinski book

Spot Curve – The spot rate is the rate of return earned by a bond when it is bought and sold on the secondary market without collecting interest payments.
The spot rate Treasury curve is a yield curve constructed using Treasury spot rates rather than yields. The actual spot rates for zero-coupon Treasury bonds are connected to form the spot rate Treasury curve.

Par Curve - A par bond is a bond priced at face value that pays regular coupons and repays the full principal at maturity. The par yield is the interest rate that makes the present value of all the bond's future cash flows (coupons + principal) equal exactly face value.

Forward curve - A forward rate is an interest rate applicable to a financial transaction that will take place in the future. It indicates the expected future interest rate or exchange rate between two currencies at a specific time.

The forward curve is a series of forward rates, each of which has the same time frame.

When spot curve is upwards sloping ⇒ longer-term investments have higher interest rates than short-term ones. This tells us that locking in money for longer gives you a higher return today.

- **Forward curve vs spot curve** - From the basic relationship between spot and forward rates, we have:

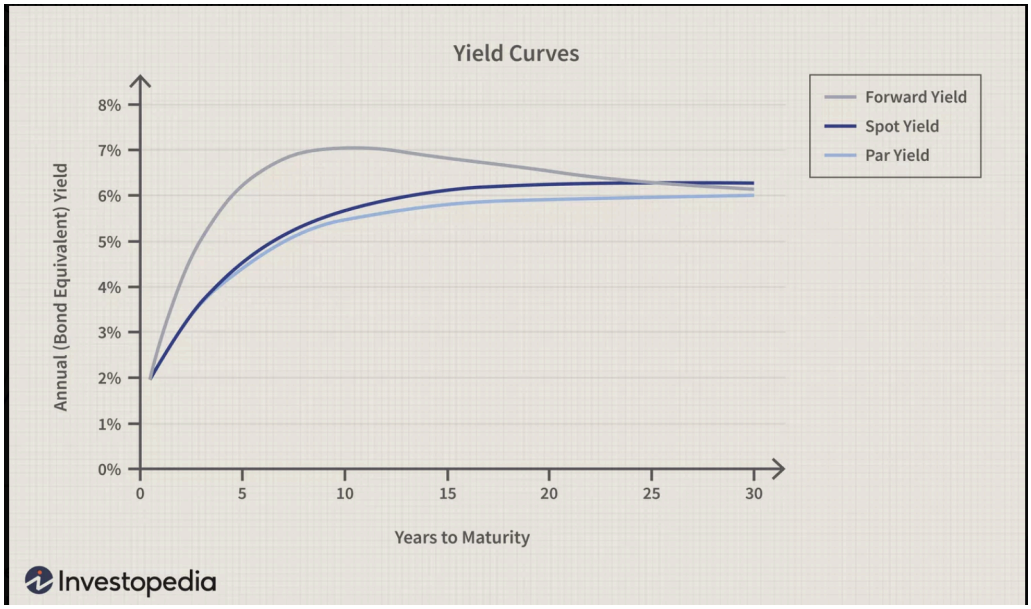
(1+ s_2)^2 = (1+s_1) * (1+$f_{1,2}$) where s_1 and s_2 are spot rates for maturity 1 and 2 years and $f_{1,2}$ is forward rate between the two years. If the spot curve is rising — meaning $s_2 > s_1$ — then this formula gives us a forward rate > s_2

⇒ When the spot curve is upward sloping, forward rates are higher than current spot rates.

That means the forward curve lies **above** the spot curve.

- **Par curve vs spot curve** - Coupons are paid earlier for at par bonds. These early payments are discounted using lower spot rates (because short-term spot rates are lower).Only the final principal payment is discounted using the higher long-term spot rate. So the average discount rate applied to the bond's cash flows is **less than the long-term spot rate**.The par yield — which is like a weighted average of spot rates — ends up being **less than** the final spot rate.

  So the par curve lies **below** the spot curve when the spot curve is rising.



Answer 13-

Sources – investopedia.com, analystprep.com, CFA curriculum, Capinski book

Yield curve and the Economic Expectations -

- The yield curve shows how interest rates vary across bonds of different maturities (e.g., 1-year, 5-year, 10-year government bonds).

- Its shape gives clues about what investors expect to happen in the economy — like interest rate trends, inflation, and growth.

Theories to explain the Shape of the Yield Curve are -

Expectations Theory, Liquidity Preference Theory, Market Segmentation Theory, Preferred Habitat Theory

One Theory - <u>The Expectations Theory</u>

Among these, I chose the Expectations Theory because it directly ties the shape of the curve to interest rate expectations.

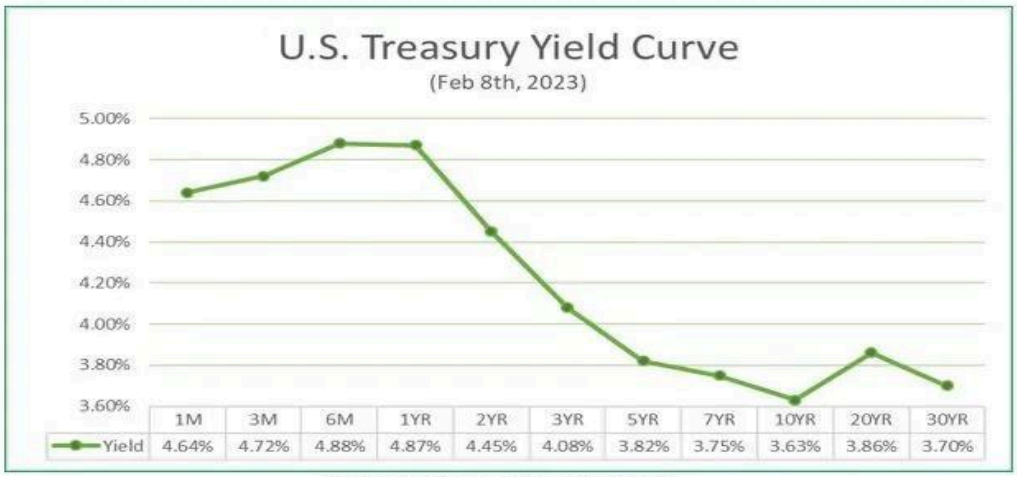
This theory says the shape of the yield curve reflects **what the market expects future short-term interest rates to be.** According to this theory:

- An **upward-sloping yield curve** means investors expect **short-term rates to rise** in the future.
- This typically reflects **economic growth**, possible **inflation**, and future **monetary tightening** by central banks.
- Long-term bonds offer higher yields to make up for the anticipated rise in rates.

Current Shape of the Yield Curve

- The yield curve is currently **inverted** – short-term yields are higher than long-term ones.
- This is often a sign of **economic pessimism** or a forecasted **recession**, as investors expect interest rates to **fall** going forward.
- Investors are moving money into long-term bonds for safety, which pushes long-term yields down.

Figure 2:



Source: FCIS Research and Analytics

The above image is as of Feb 2023, but it is still valid in the 2025 context as the U.S. yield curve remains inverted in 2025 as well.

Answer 14 -

Sources – investopedia.com, corporatefinanceinstitute.com, CFA curriculum

Credit Spreads / Yield Spreads -

- A credit spread (or yield spread) refers to the difference in yield between a corporate bond and a risk-free government bond of the same maturity.
- It compensates investors for credit risk, i.e., the risk that the bond issuer might default.
- Yield spread = Yield on corporate bond – Yield on treasury/government bond

Relationship Between Credit Rating and Yield Spread -

- Credit ratings reflect the creditworthiness of a bond issuer, assigned by agencies like S&P, Moody's, or Fitch.
- Ratings range from AAA (prime quality) to junk-grade (speculative or default risk)**.**

Key Idea:
Higher credit rating -> Lower credit risk -> Narrower yield spread

Lower credit rating -> Higher credit risk -> Wider yield spread

- **Investors demand more yield** (i.e., higher spread) when lending to riskier issuers to **compensate for default risk**.

- Example:
  AAA-rated bond might have a 1% spread
  BB-rated (junk) bond could have a 5%+ spread

- During uncertain economic conditions, spreads **widen more** for lower-rated bonds.

Hence,

- Credit spreads are **inversely related** to credit ratings.
- A high-quality bond = **lower yield spread**, low risk.
- A low-rated bond = **higher yield spread**, higher risk and volatility.