The grading notes in this sheet are REPRESENTATIVE and not complete. There were too many combinations of answer to write down every grading rule.

1. Warm-Up with Short Answer Questions (15 minutes; 15 total points)

A. What is the one-year forward rate from yr5 to yr6 given The zero coupon rates below?

-2pts Forgetting to minus the one
-5pts Wrong exponents
-4pts Wrong years

$$1+ f_{5,6} = \frac{(1+r_6)^6}{(1+r_5)^5}$$

$$f_{5,6} = \frac{(1.0390)^6}{(1.0320)^5} - 1$$

Q1A: **7.47%**
5 points

B. Which of the following is a necessary input to the Black-Derman-Toy model (Check all that apply):

- ☐ The coupon yield curve
- ✓ The zero-coupon yield curve
- ☐ The volatilities of coupon rates
- ✓ The volatilities of zero-coupon bonds
- ☐ The covariance matrix of zero-coupon bonds
- ☐ The relative amounts (weights) of zero-coupon bonds
- ☐ The amount of riskfree assets in the economy
- ☐ The weight of the riskfree asset in the economy
- ☐ The expected return on the market portfolio

Q1B: **5 points**

2 correct; 0 wrong = 5pts
1 correct; 0 wrong = 3pts
2 correct; 1 wrong = 1pt
1 correct; 1 wrong = 0pts
2 correct; 2 wrong = 0pts

C. Use goal seek to find "*x*" such that:

$$0.70x^4 - 0.50x^3 + 0.30x^2 + 0.30x - 0.05 = 0$$

3pts If coefficients are wrong, but otherwise correct

Q1C: 0.149
5 points

Some round-off error allowed.
Also ***-0.5251*** *works*

2. Outperformance Options (55 minutes; 55 total points)

A. Use Monte Carlo analysis and your simulated stock price to estimate the price of the European call option described above. Save the output from the Monte Carlo in a worksheet named "2A".

Q2A: Value of Call(HSBC) **$8.57**
10 points (s.e. of 0.15)

General Grading Guidelines (many mistakes were unique)

-7pts	*If you use drift of 20% (but no double jeopardy on other questions)*
-3pts	*If answer is close but more than 3 stderrs away*
+1pt	*For generating uniform random numbers*
+1pt	*For inverting uniforms to get normal random numbers*
+1pt	*For getting daily drift and daily volatility right*
+0pts	*For trying to marry the Black-Scholes formula with Monte Carlo methods*
-4pts	*For simulating 1 month only*
-2pts	*For simulating a year only (and not following the directions re: monthly)*
2pts	*TOTAL if your call option price is near $65 or near $0 (no economic sense)*
-5pts	*For doing an Asian or lookback option*
-7pts	*For confusing input values such as 1.00 and 1.00% (the former is 100x as large)*

B. Use Monte Carlo analysis and your simulated stock price to estimate the price of a European call option. Save the output from the Monte Carlo in a worksheet named "2B".

Q2B: Value of Call(ETF) **$ 5.08**
5 points (s.e. of 0.08)

General Grading Guidelines (many mistakes were unique)

3pts	*If repeat of all mistakes from above (many)*
5pts	*If repeat of all mistakes from above (few)*

C. How much is an outperformance call option on HSBC (vs. the ETF) worth? Save the output from the Monte Carlo in a worksheet named "2C".

Q2C: Value of Outperf Option **$9.61** 15 points (s.e. of 0.16)

-7pts For applying the same shock to both HSBC and ETF
-7pts For not calculating outperformance correctly
+8pts For calculating outperformance correctly
-3pts No discounting
-3pts If answer is close but more than 3 stderrs away
-3pts For incorrect input numbers

D. Assume that HSBC's returns and the ETFs returns have a 0.58 correlation coefficient. Now recalculate how much the outperformance call option on HSBC (vs. the ETF) is worth. Save the output from the Monte Carlo in a worksheet named "2D".

Q2D: Outperf. Opt w/ $\rho = 0.58$ **$ 6.98** 15 points (s.e. of 0.12)

-10pts For not implementing the correlation formula correctly.
-15pts For ignoring correlation all together
-7pts For not making HSBC rely on shock 1 and ETF rely on shock 2
+3pts For an attempt that includes correlation (maybe on uniform randoms)
10pts Max if your answer to 2D is higher than 2C
-3pts For incorrect input numbers

E. Format your spreadsheet so that the HSBC and ETF inputs are clearly displayed.

Q2E: **10 points**

We are going to be a little tough on the formatting criteria
No graph: -3 points
Graph not linked to correlated prices: -1 point
Inputs not clear (i.e. no green): -5 points
Unformatted numbers: -1 point
Input cells scattered around spreadsheet: -2pts
Inputs embedded in cells: -3pts
General messiness (opposite of "ease of use"): -1pt to -4pts

Learning point: Think about why most CEOs prefer traditional options on their own company's stock rather than outperformance options.

A CEO who must outperform an industry benchmark (index) generally has less upside potential. Since the stock and index are highly correlated, the volatility of the difference is low. The value of a call option increases with volatility. Outperformance can be less volatility than the underlying stock, thus outperformance options may be worth less than options on single stocks.

3. Bond Portfolio Optimization (50 minutes; 50 total points)

A. Use Excel's "PRICE" function to find the price per bond for each of the three bonds. As shown on the next page, the price of the first bond has been calculated for you.

Q3A:	Price of Bond(i)	100.9212
	Price of Bond(ii)	**96.9704**
	Price of Bond(iii)	**101.7416**
	10 points	

-5pts For not using the PRICE function correctly
-3pts For typo errors

B. Use Excel's "DURATION" function to find each bond's weighted average life (WAL).

Q3B:	Wgt Avg Life of Bond(i)	4.7186
	Wgt Avg Life of Bond(ii)	**8.0740**
	Wgt Avg Life of Bond(iii)	**12.2278**
	5 points	

C. Use Excel's "mduration" function to find each bond's modified duration.

Q3C:	Mod Duration Bond(i)	4.5901
	Mod Duration Bond(ii)	**7.6603**
	Mod Duration Bond(iii)	**11.5520**
	5 points	

D. Now use the total cashflows to calculate the "All-In YTM". This is the CEO's average cost of borrowing

Q3D: All-In YMT **5.1338%**

15 points

+8pts For getting all cash flows correct
-7pts If your YTM doesn't take into account time value of money
15pts For using "Goal Seek" to manually calculate the YTM
-7pts If we gave you YTM formula
-2pts If goal seek gets an incorrect value
-2pts If put incorrect bond holding numbers

E. Figure out how the CEO can achieve the lowest cost of all-in borrowing. Use Excel's Solver to choose how many of each bond to hold in your portfolio.

Q3E:	Number of Bonds(i)	**8,688**
	Number of Bonds(ii)	**0**
	Number of Bonds(iii)	**11,040**
	15 points	

+3pts For calculating the Mod Dur of the portfolio
+2pts Choosing correct cells that Solver can change
+3pts Setting Solver to minimize YTM
-7pts If your YTM doesn't take into account time value of money
+15pts If your Solver works correctly but your all-in YTM formula in Part D is incorrect
6pts In total (regardless of other) if Solver is almost there but YTM is causing problems
-2pts Incorrect duration constraint
-2pts Incorrect portfolio weights

You could have gotten almost full points for #3E even without knowing about the IRR in #3D. We checked to see if your had Solver set up correctly.

Learning point: This "Optimal" solution

This solution creates a "barbell" structure. There is a big payment in five years. The CFO may find raising all the cash difficult. While the duration is 8.5, it might be optimal for the CFO to arrange a smoother payment stream.

4. Do only if you have time (5 points)

Use Monte Carol analysis to estimate the value of π (called "pi").

The idea is to throw darts and see what area they land in. The ratio of the actual areas will be equal to the ratio of where the darts hit. Below are step-by-step directions.

My estimated value of π is: **3.1404**

0pts *For simply writing 3.1415926 (we already knew the answer)*
-2pts *For not knowing how to convert the 0.78511 "hit ratio" into "pi" by multiplying by 4*
+3pts *If almost correct*

Step 1: Calculate X = 2*Rand() – 1
This generates X values between -1 and +1

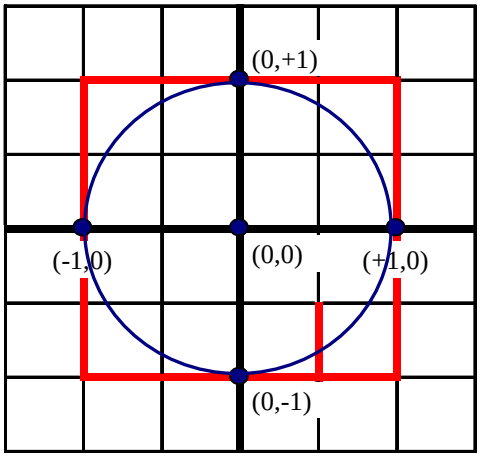
Step 2: Calculate Y = 2*Rand() – 1
This generates Y values between -1 and +1

Step 3: Hit F9 and you have a new {X,Y} pair of numbers
100% of the {X,Y} pairs will fall in the square (by design)

Step 4: Check if $X^2+Y^2 \le 1$
If so the {X,Y} pair also falls in the circle

Step 5: I found 100% of darts landed in the square while 78.511% also landed in the circle
Setting up the ratio of areas allows me to solve for π:

The Target



$$\frac{\%inCircle}{\%inSquare} = \frac{AreaCircle}{AreaSquare}$$

$$\frac{0.78511}{1.00000} = \frac{\pi r^2}{L^2}$$

$$= \frac{\pi}{2 \times 2}$$

$$4 \times 0.78511 = \pi$$