CEE 4674: Airport Planning and Design **Fall 2026**

Quiz 1 : Open Notes and Take Home

Solution Instructor: Trani

Instructions

Write your solutions in the spaces provided. Add any additional pages with calculations as needed. Make sure each additional page has your name.

Honor Code Pledge

The information provided in this exam is my own work. I have not received information from another person while doing this exam. Please sign the pledge.

_____ (your signature/name)

Problem 1 (30 Points)

Design a suitable runway length for a new airport to be constructed in land located 2,050 feet above mean sea level conditions. Twenty years of temperature data collected at the site, show a mean maximum temperature of the hottest month of the year is 27.1 degrees Celsius. The airport is expected to operate a variety of narrow-body aircraft shown in Table 1. Consultation with the airlines expected to fly to the new airport shows the desired takeoff weights required for the new runway considering the routes each airline will fly (see Table 1). During runway construction, normal terrain settlement of the clay soil and thousands of aircraft passes is likely to produce a gradient of 0.4%. Use that value in your analysis.

Table 1. Aircraft Fleet Mix to be Investigated for Runway Length Requirements for a New Airport..

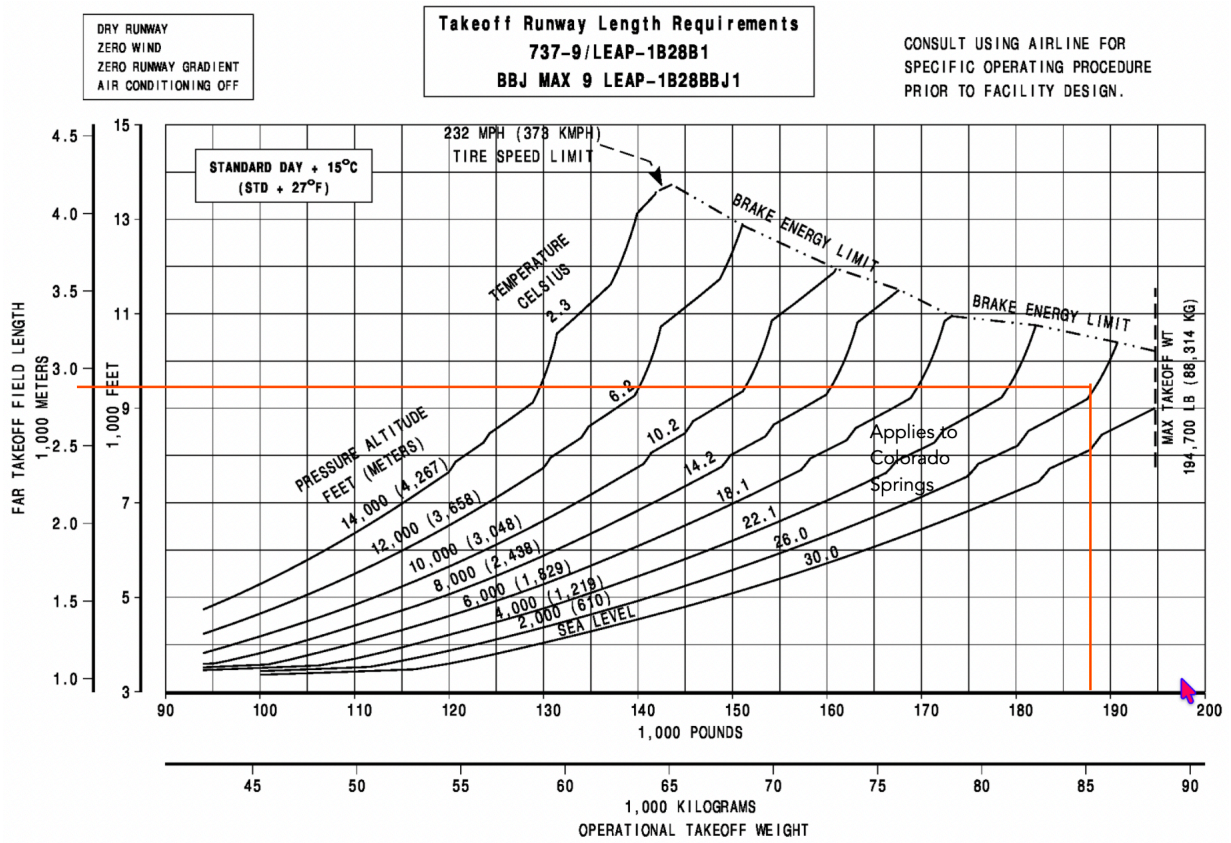
Aircraft	Engine	Desired Takeoff Weight Configuration (lbs.)
Boeing 737-9 Max	CFM Leap 1B28B1	188,000
Airbus A321-200	CFM56 series	195,000
Airbus A321neo	LEAP-1A series	205,000

Task A

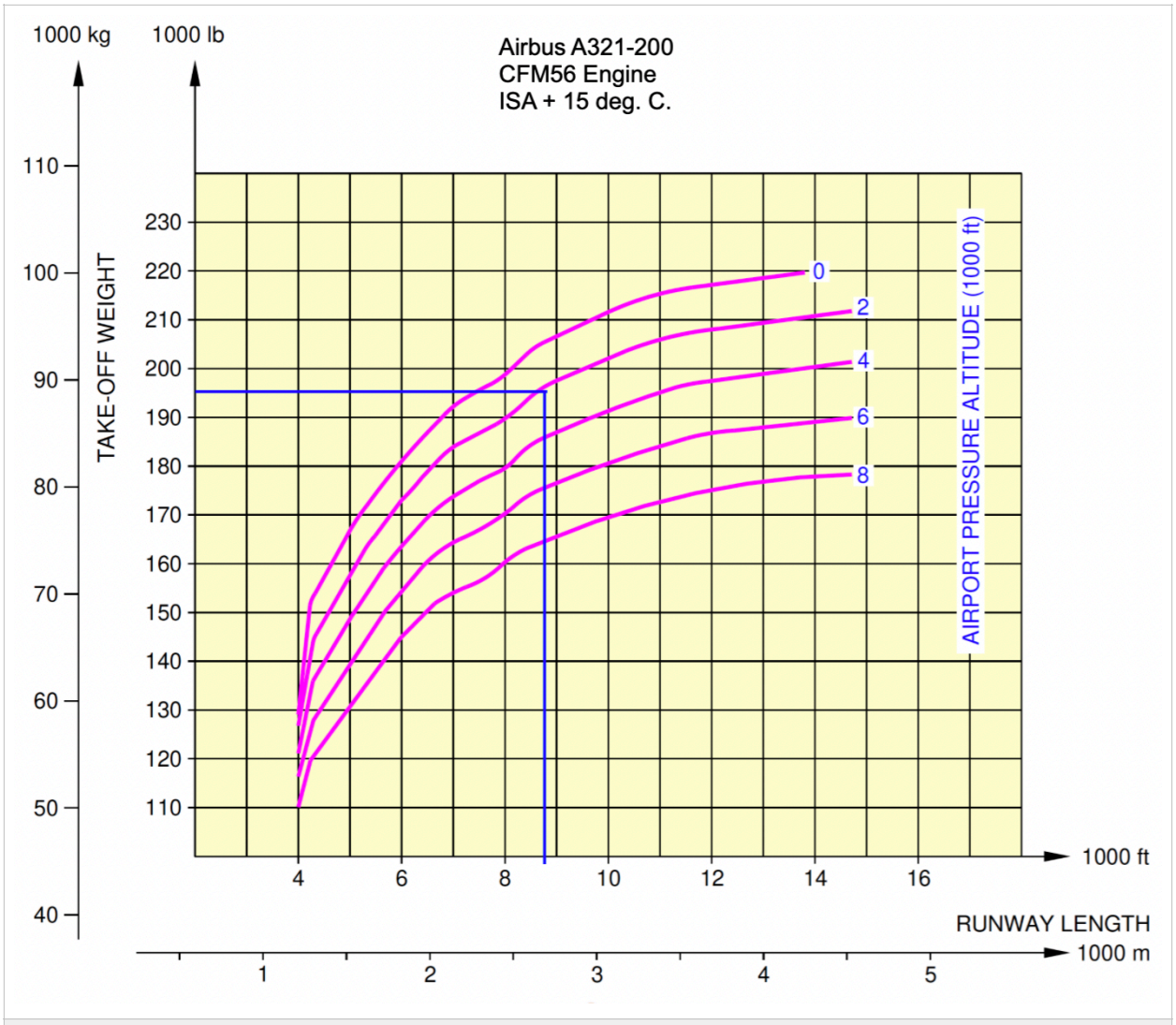
Find the runway length required to serve the aircraft fleet mix anticipated at the airport (see Table 1). Design the runway allowing operations considering the desired takeoff weight conditions in Table 1 for each aircraft. In your solution list the takeoff and landing requirements for each aircraft and your final runway length recommendation. Also, indicate the figures used in the airport planning documents for each aircraft.

At 2,050 feet elevation the ISA temperature is 10.9 deg. C. Therefore, the design temperature at the airport for runway length calculations is: ISA + 16.2 Celsius. The value is less than 1.7 degrees Celsius from ISA + 15 deg. C. Therefore, we use ISA + 15 deg. C. Conditions.

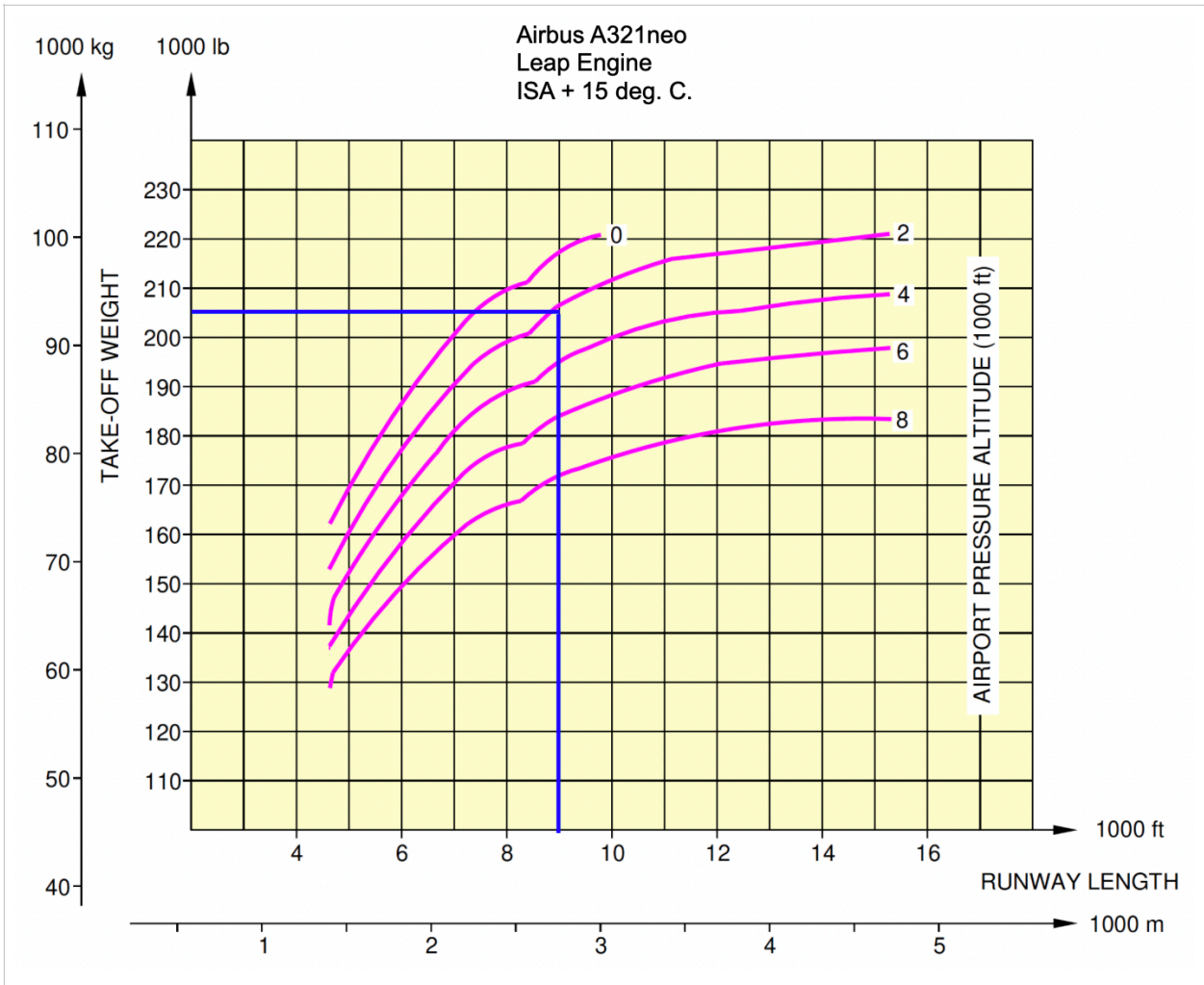
Aircraft	Boeing 737-9 Max CFM Leap 1B28B1	Airbus A321-200 CFM56 series	Airbus A321neo LEAP-1A series
DTW (lbs)	188,000	195,000	205,000
Takeoff Field Length (ft)	9,400	8,800	9,000
Critical Takeoff Runway Length (feet)	9,400		
Corrected Takeoff Field Length (ft)	9,776 (round to 9,800 feet)		
Landing Distance (ft)	6,800 At (Wet)	6,600 At 185,000 lbs. (Unknown pavement condition)	5,600 At 178,000 lbs. (Unknown pavement condition)
Figure in Aircraft Planning Document for Takeoff Distance	3.3.22	3-3-2-991-007-A01	3-3-2-991-010-A01



Boeing 737-9Max Takeoff Performance. ISA + 15 deg. C.



Airbus A321-200 with CFM56 Engine Takeoff Performance. ISA + 15 deg. C.



Airbus A321neo with LEAP-1A series Engine Takeoff Performance. ISA + 15 deg. C.

The critical aircraft is the Boeing 737-9Max. The design runway should be 9,800 feet after correcting for runway grade.

Task B

For the Boeing 737-9 operating from the runway length in Task A, find the maximum permissible payload if the airline would like to fly airport pair routes located 2,000 nautical miles away.

DTW = 188,00 lbs
Route distance = 2,000 nm
OEW + PYL = 156,000 lbs
OEW = 47,500 kilograms (104,720 lbs.)
Payload is 51,280 lbs.
Fuel = 32,000 lbs

Task C

For the Boeing 737-9 solution found in Task B, estimate the cargo and passenger loads for your solution in Task B. Assume the aircraft seats are full. Use a two-seating layout configuration and assume the operating empty weight of the aircraft according to the airline is 47,500 kilograms.

Two-class seating = 193 seats
Passenger weight = (220 lbs/seat)(193 seats) = 42,460 lbs.
Belly cargo weight = 51,280 lbs - 42,460 lbs = 8,820 lbs.

Task D

For the Boeing 737-9 find the average fuel used per passenger (in kilograms) to fly the 2,000 nm route with all seats full.

Fuel = 32,000 lbs
Two-class seating = 193 seats
Fuel per passenger = 165.8 lbs. (522.3 lbs of CO_2)

Problem 2 (25 Points)

Use the Small Aircraft Runway Length Analysis Tool (SARLAT) to evaluate the existing runway conditions at Garrett County Airport (2G4) in Maryland. The airport serves single, multi-engine piston, turboprop and jet powered aircraft (see Table 2). Table 2 was generated as part of a new master plan for the airport. In your analysis consider climate change effects with temperatures projected for the year 2040.

Table 2. Aircraft Fleet Mix for Problem 2.

Aircraft Type	Aircraft	Annual Operations
Piston	Cirrus SR20	2450
Piston	Cessna 182	3560
Piston	Cessna 172	2800
Turboprop	Beechcraft King B200GT	560
Turboprop	Pilatus PC12	880
Turboprop	Cessna Caravan	260
Jet	Cessna 560 XL	620
Jet	Embraer Phenom 100	510
Jet	Cessna Citation M2	356
Total		11640

Task A

Is the existing runway length available at the airport suitable for corporate jet and turboprop operations at 80% useful load when the runway pavement is dry? Explain.

Elevation: 2933.4 feet
Runway 9/27 is 5000 x 75 ft.
Elevation of threshold 9 : 2933.1 ft.
Elevation of threshold 27: 2876.9 ft.
Average slope : 1.1%
Projected temperature in 2040 (higher emissions): 82 deg. Fahrenheit

Piston Aircraft Operations:
The 5,000-foot runway is good for all piston aircraft operations. The 5,000-foot runway allows all piston-powered aircraft to operate at 100% useful load.

Turboprop Aircraft Operations:
The 5,000-foot runway is good for all turboprop operations. The 5,000-foot runway allows all turboprops to operate at 100% useful load.

Jet Aircraft Operations:
The 5,000-foot runway falls short for the Phenom 100. The Cessna 560XL and the Cess Citation M2 can operate at 84% and 90% useful load, respectively (from a dry runway). The Phenom can operate at 66% of useful load from the existing airport in dry runway conditions (see the figure below).

Aircraft Name	Aircraft Mix	NBAA IFR Maximum Range		Useful Load (Takeoff Weight)		Landing at NBAA Minimum IFR Reserves					
						Part 91		Part 135 EOD		Part 135/91K	
		Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet
Turboprop											
BE20 - Beechcraft King Air B200GT	4%	100 % FLIGHTS IN NAS 914 nm / 4 pax	100 % FLIGHTS IN NAS 914 nm / 4 pax	100 % 12500 lbs	100 % 12500 lbs	✓	✓			✓	✓
C208 - Cessna 208 Caravan	2%			100 % 8000 lbs	100 % 8000 lbs	✓	✓			✓	✓
PC12 - Pilatus PC 12 NG	7%			100 % 10450 lbs	100 % 10450 lbs	✓	✓			✓	✓
Jet											
C56X - Cessna 560 XL	5%	100 % FLIGHTS IN NAS 1238 nm / 4 pax	83 % FLIGHTS IN NAS 770 nm / 4 pax	84 % 19035 lbs	65 % 17620 lbs	✓	✓	✓	✓	✗	✗
C25M - Cessna Citation M2	3%	100 % FLIGHTS IN NAS 897 nm / 3 pax	88 % FLIGHTS IN NAS 666 nm / 3 pax	90 % 10336 lbs	77 % 9847 lbs	✓	✓	✓	✓	✓	✗
E50P - Phenom 100	4%	85 % FLIGHTS IN NAS 548 nm / 3 pax	38 % FLIGHTS IN NAS 223 nm / 3 pax	66 % 9264 lbs	48 % 8624 lbs	✓	✓	✓	✓	✓	✗

Task B

Examine the solution in Task (a), and identify the most critical aircraft operating at the airport. Consider annual aircraft operations in your answer.

The Phenom 100 has 510 operations. Hence it is the critical aircraft. You can verify that by running a design case.

Task C

With the existing runway length available, find how far can a Cessna 560XL fly with the typical passenger load departing from a dry runway.

The Cessna 560XLS can fly 1238 nm with four passengers and two pilots departing the 5,000-foot runway (dry). The range is reduced to 773 nm if the 5,000-foot runway is wet.

Task D

Propose runway length improvements if larger corporate jets are introduced in the future. Specifically, consider operations with the Dassault Falcon 2000 and Cessna Citation Latitude. The design goal is to provide enough runway to fly all jets at 80% useful load with dry runway conditions.

The runway would have to be extended to 7,100 feet to satisfy the 80% useful load constraint for all jets including the Falcon 2000EX (see figure below) .The Falcon 2000 is the most demanding aircraft of the set.

Consider the sensitivity of the solution. If the Falcon 2000EX is removed from the future set, a 5,540 feet (540-foot runway extension), will allow the Cessna Latitude and the original jets to operate at or above 80% useful load. With a 540-foot runway extension, the Falcon 2000EX would be able to operate at 64% of useful load. That would be sufficient to fly 2,019 nm with the average passenger load and two pilots. Note that a Falcon 2000EX able to fly 2,019 nm can fly 100% of the typical trips in the domestic flights in the United States.

Aircraft Name	Aircraft Mix	NBAA IFR Maximum Range		Useful Load (Takeoff Weight)		Landing at NBAA Minimum IFR Reserves					
						Part 91		Part 135 EOD		Part 135/91K	
		Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet
Jet											
C56X - Cessna 560 XL	5%	100 % FLIGHTS IN NAS 1620 nm / 4 pax	100 % FLIGHTS IN NAS 1620 nm / 4 pax	100 % 20200 lbs	100 % 20200 lbs	✓	✓	✓	✓	✓	✓
C68A - Cessna Citation Latitude	4%	100 % FLIGHTS IN NAS 2135 nm / 5 pax	100 % FLIGHTS IN NAS 2135 nm / 5 pax	100 % 30800 lbs	100 % 30800 lbs	✓	✓	✓	✓	✓	✓
C25M - Cessna Citation M2	3%	100 % FLIGHTS IN NAS 1074 nm / 3 pax	100 % FLIGHTS IN NAS 1074 nm / 3 pax	100 % 10700 lbs	100 % 10700 lbs	✓	✓	✓	✓	✓	✓
F2TH - Dassault Falcon 2000EX	4%	100 % FLIGHTS IN NAS 2807 nm / 6 pax	100 % FLIGHTS IN NAS 2367 nm / 6 pax	80 % 37952 lbs	71 % 36196 lbs	✓	✓	✓	✓	✓	✓
E50P - Phenom 100	4%	100 % FLIGHTS IN NAS 1047 nm / 3 pax	100 % FLIGHTS IN NAS 1006 nm / 3 pax	100 % 10470 lbs	92 % 10199 lbs	✓	✓	✓	✓	✓	✓

Problem 3 (20 Points)

Consider the existing conditions at Garrett County Airport (2G4) in Maryland. Refer to Problem 2.

Task A

Considering the existing airport fleet mix shown in Table 2, find dimensions of the RPZ, RSA and ROFA needs at the airport. According to Airnav, the runway is a non-precision runway with approach visibility minima of 2 miles or more. Clearly state the RDC Code of the airport considering the population in Table 2.

RDC is B-II-10000 , RDC B-II-5000 also acceptable

Use Table G-4 Runway Design Standards Matrix, A/B-II using the second column of the table (visibility not lower than 1 mile).

Notes:
1) The Table G-3 applies to small aircraft (with maximum takeoff weights at or below 12,500 lbs.)
2) The runway is not a vital runway (based on the description of the problem) because the visibility is 2 miles and Arnav information.

***RPZ dimensions** for approach and departure are the same:*
Length = 1,000 feet
Inner width = 500 feet
Outer width = 700 feet

RSA dimensions
Length beyond departure end = 300 feet
Length prior to threshold = 300 feet
Width = 150 feet

ROFA dimensions
Length beyond departure end = 300 feet
Length prior to threshold = 300 feet
Width = 500 feet

Table G-4. Runway Design Standards Matrix, A/B–II

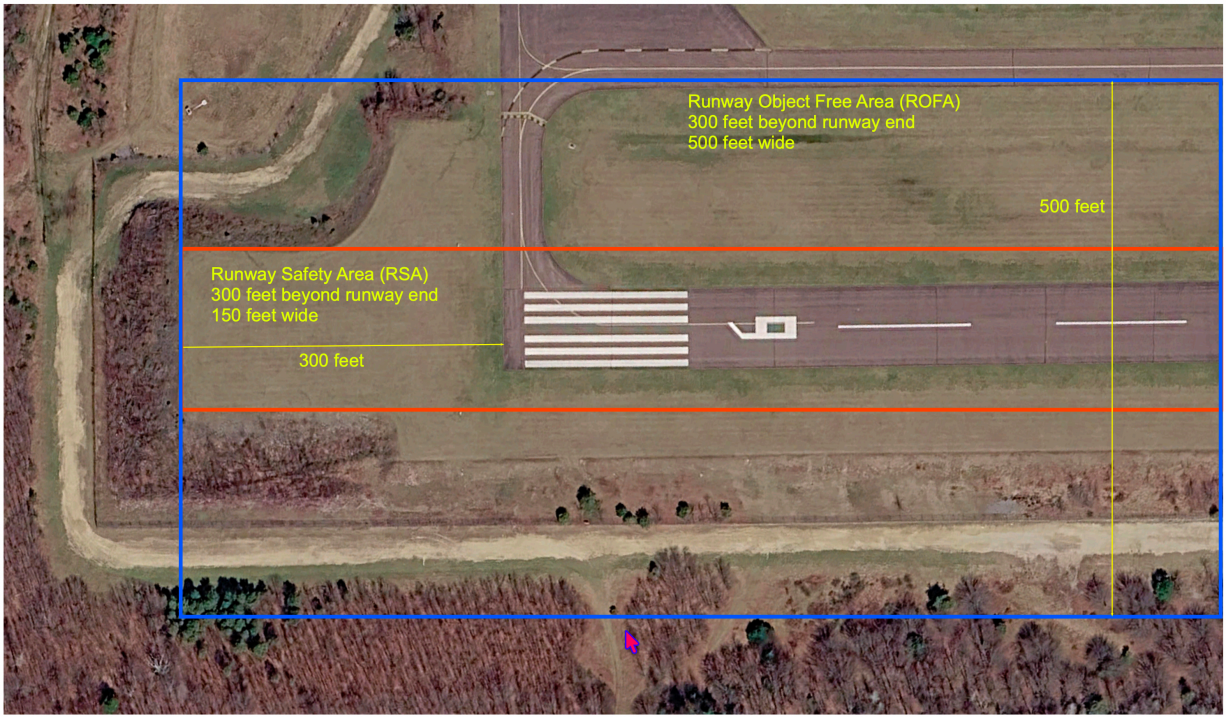
Aircraft Approach Category (AAC) and Airplane Design Group (ADG):		A/B – II			
ITEM	DIM [1]	VISIBILITY MINIMUMS			
		Visual	Not Lower than 1 mile	Not Lower than 3/4 mile	Lower than 3/4 mile
RUNWAY DESIGN					
Runway Length	A		*Refer to paragraphs 3.3 and 3.7.1*		
Runway Width	B	75 ft	75 ft	75 ft	100 ft
Shoulder Width		10 ft	10 ft	10 ft	10 ft
Blast Pad Width		95 ft	95 ft	95 ft	120 ft
Blast Pad Length		150 ft	150 ft	150 ft	150 ft
Crosswind Component		13 knots	13 knots	13 knots	13 knots
RUNWAY PROTECTION					
Runway Safety Area (RSA)					
Length beyond departure end [9, 10]	R	300 ft	300 ft	300 ft	600 ft
Length prior to threshold	P	300 ft	300 ft	300 ft	600 ft
Width	C	150 ft	150 ft	150 ft	300 ft
Runway Object Free Area (ROFA)					
Length beyond runway end	R	300 ft	300 ft	300 ft	600 ft
Length prior to threshold	P	300 ft	300 ft	300 ft	600 ft
Width	Q	500 ft	500 ft	500 ft	800 ft
Obstacle Free Zone (OFZ)					
Runway, Inner-approach, Inner-Transitional			*Refer to paragraph 3.11*		
Precision Obstacle Free Zone (POFZ)					
Length		N/A	N/A	N/A	200 ft
Width		N/A	N/A	N/A	800 ft
Approach Runway Protection Zone (RPZ)					
Length	L	1,000 ft	1,000 ft	1,700 ft	2,500 ft
Inner Width	U	500 ft	500 ft	1,000 ft	1,000 ft
Outer Width	V	700 ft	700 ft	1,510 ft	1,750 ft
Departure Runway Protection Zone (RPZ)					
Length	L	1,000 ft	1,000 ft	1,000 ft	1,000 ft
Inner Width	U	500 ft	500 ft	500 ft	500 ft
Outer Width	V	700 ft	700 ft	700 ft	700 ft

Runway Design Conditions for Garrett County Airport (2G4) if the Critical Aircraft is B-II.

Task B

Are the RSA and ROFA areas protected at the airport? Comment.

The RSA area is protected (300 feet beyond the runway end). The ROFA has issues and does not seem to be protected: the ROFA is penetrated by trees to the South and a taxiway to the North (see the figure below).



Runway 9 Threshold at Garrett County Airport (2G4) Maryland.

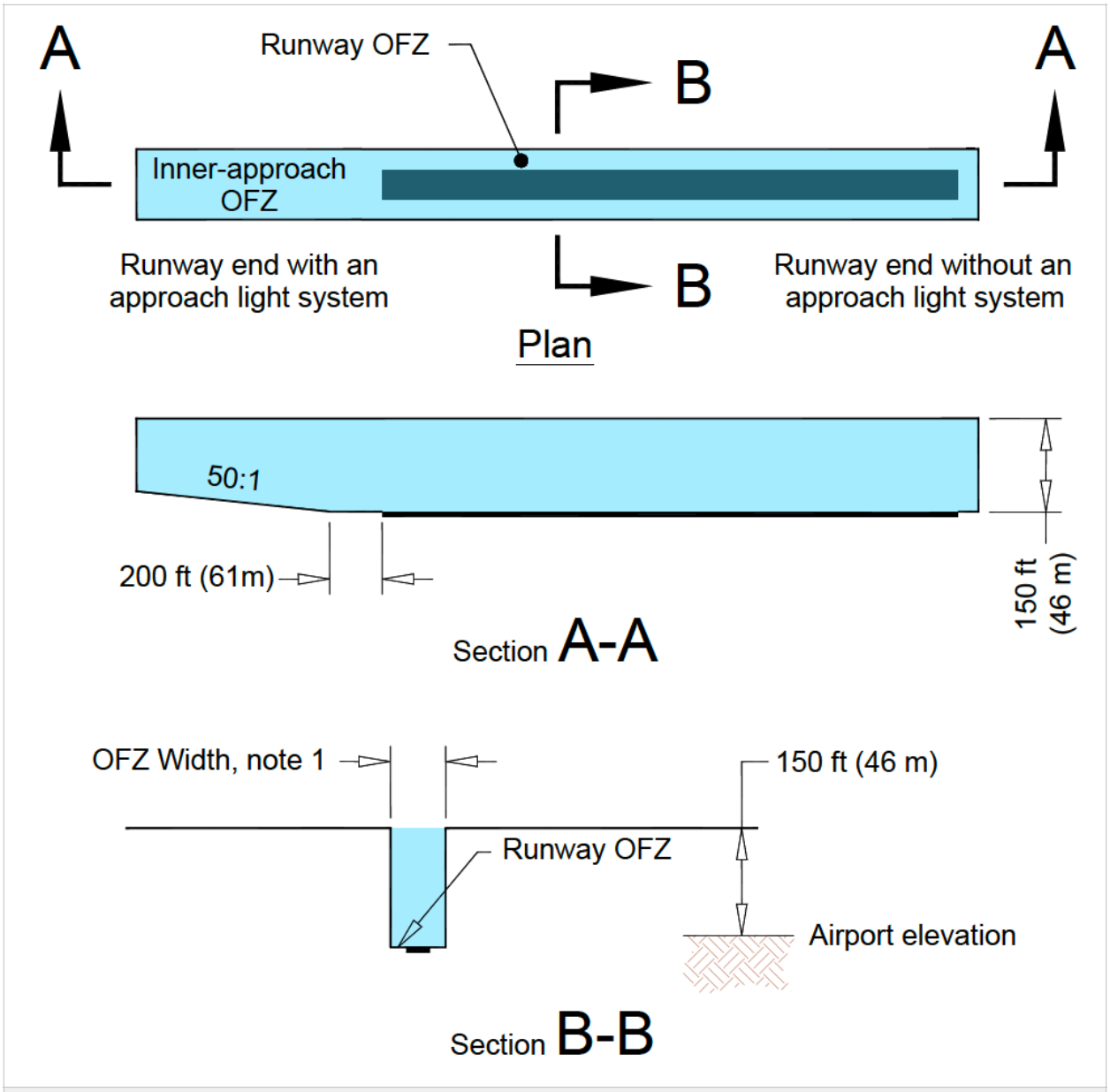
Task C

State the dimensions of the various OFZ surfaces at the airport.

The runway OFZ for runways served by large aircraft (Max. Takeoff Weight > 12,500 lbs.) is: 400 feet (122 m) wide for operations. Note. The Cessna 560XLS is a large aircraft (>12,500 lbs).

The figure below illustrates the OFZ shape and dimensions for the airport. Since the airport has no approach lights, the runway OFZ ends 200 feet from the runway ends (both runway 9 and 27). The runway 9/27 has not inner approach OFZ surface.

The runway OFZ has a vertical sides starting 200 feet from the runway centerline. The vertical rise is 150 feet until reaching the horizontal surface (see figure below).



Runway OFZ Surfaces for Garrett County Airport (2G4). Applies to Runways

Task D

If the new aircraft (see Task D in Problem 2) are introduced in the future, how will the RSA and ROFA surfaces be impacted. Explain.

If the Falcon 2000EX is introduced in the future, the airport transitions from RDC B-II to C-II with significant changes in the design criteria. The design characteristics for C-II are shown in Table G-8 in the FAA AC 150/5300-13b and repeated below. There are significant changes to the RSA and ROFA surfaces.

RSA increases to 1,000 feet in length (from 300 feet). The width of the RSA is 500 feet instead of 150 feet. The ROFA width increases from 500 to 800 feet. The RPZ increases by 700 feet in length.

Aircraft Approach Category (AAC) and Airplane Design Group (ADG):		C/D/E – II			
ITEM	DIM [1]	VISIBILITY MINIMUMS			
		Visual	Not Lower than 1 mile	Not Lower than 3/4 mile	Lower than 3/4 mile
RUNWAY DESIGN					
Runway Length	A		*Refer to paragraphs* 3.3 *and* 3.7.1		
Runway Width	B	100 ft	100 ft	100 ft	100 ft
Shoulder Width		10 ft	10 ft	10 ft	10 ft
Blast Pad Width		120 ft	120 ft	120 ft	120 ft
Blast Pad Length		150 ft	150 ft	150 ft	150 ft
Crosswind Component		16 knots	16 knots	16 knots	16 knots
RUNWAY PROTECTION					
Runway Safety Area (RSA)					
Length beyond departure end [9, 10]	R	1,000 ft	1,000 ft	1,000 ft	1,000 ft
Length prior to threshold [11]	P	600 ft	600 ft	600 ft	600 ft
Width [13]	C	500 ft	500 ft	500 ft	500 ft
Runway Object Free Area (ROFA)					
Length beyond runway end	R	1,000 ft	1,000 ft	1,000 ft	1,000 ft
Length prior to threshold [11]	P	600 ft	600 ft	600 ft	600 ft
Width	Q	800 ft	800 ft	800 ft	800 ft
Obstacle Free Zone (OFZ)					
Runway, Inner-approach, Inner-Transitional			*Refer to paragraph* 3.11		
Precision Obstacle Free Zone (POFZ)					
Length		N/A	N/A	N/A	200 ft
Width		N/A	N/A	N/A	800 ft
Approach Runway Protection Zone (RPZ)					
Length	L	1,700 ft	1,700 ft	1,700 ft	2,500 ft
Inner Width	U	500 ft	500 ft	1,000 ft	1,000 ft
Outer Width	V	1,010 ft	1,010 ft	1,510 ft	1,750 ft
Departure Runway Protection Zone (RPZ)					
Length	L	1,700 ft	1,700 ft	1,700 ft	1,700 ft
Inner Width	U	500 ft	500 ft	500 ft	500 ft
Outer Width	V	1,010 ft	1,010 ft	1,010 ft	1,010 ft
RUNWAY SEPARATION					
Runway centerline to:					
Parallel runway centerline	H		*Refer to paragraph* 3.9		
Holding Position		250 ft	250 ft	250 ft	250 ft
Parallel taxiway/taxilane centerline [2]	D	300 ft	300 ft	300 ft	400 ft
Aircraft parking area	G	*Refer to paragraph* 3			
Helicopter touchdown pad		*Refer to* AC 150/5390-2			

Note 1: Values in the table are rounded to the nearest foot. 1 foot = 0.305 meters.
Note 2: See the Footnotes on the page after Table G-12.

Runway Design Conditions for Garrett County Airport (2G4) if the Critical Aircraft is C-II.

Problem 4 (25 points)

Short answer or true/false. Show your calculations.

	Question	Short Answer
1	Name the AAC group for the Airbus A321neo.	C
2	Runway 09 at San Diego Airport (SAN) is a precision runway with approach lights. (True/False)	TRUE
3	Roanoke-Blacksburg Regional Airport (ROA) has an EMAS to protect against landing overruns on runway 06. (True/False)	FALSE
4	Name the Global Express 6000 taxiway design group.	2B
3	A Boeing 757-200 departing LGA on runway 13 is able to stop on the EMAS while traveling at 50 knots. (True/False)	EMAS is 325 feet long True 53 knot exit speed
4	Aircraft design group for the Boeing 767-400.	IV
5	Approach speed (in knots) of the Boeing 747-8 landing at 688,000 lbs.	159 From ACD
6	An engineer reports a design temperature of ISA+20 degrees Celsius at an airport located 3,100 feet above sea level conditions. Find the design temperature in degrees Fahrenheit.	84
7	Distance from the end of the runway to the end of the inner-approach OFZ for a runway with a 2,400-foot lighting system.	2,600 feet
8	Change in the length of the RSA dimension when the airport transitions from B-II to C-II. Assume visibility is not lower than one mile.	700 feet
9	Name the AAC group for the Airbus A321neo.	C
10	Route distance for planning to fly from Dulles Airport to Munich International Airport.	3929 nm 4519 sm