Name: _____

○ COS 480 students should answer non-⋆ questions; optional ⋆ questions are for extra credit.
○ COS 580 students should answer all questions, including ⋆ questions.
○ Some questions refer to the database suggested by Figure 1 on the last page. You may detach that page for easy reference. There is no need to reattach it.
○ Reminder: In all query-writing questions, your answers should work on *all* database instances, not only the instance of Figure 1.

1. (1 pt.) Write your name in the space provided above.

2. (9 pts.) Indicate the result of evaluating the following query on the database instance of Figure 1.

```
select T.type, sum(T.height) as XHt
from Trees T, Places P
where T.dia >= 3 * P.zone
group by T.type
```

3. (14 pts.) Write SQL queries as directed below.

(a) We say a tree with `minz` a and `maxz` b *grows well* in a city with zone z if $a \leq z \leq b$. Write a SQL query to find names of trees that grow well in at least one city in Maine with a population greater than 5000. The result should be sorted in descending name order, with no duplicates.

(b) Write a SQL query to find the thickest (maximum diameter) trees that grow well (see Question 3a) in each city in Maine. The output should consist of tuples of the form (c, t), where t is the name of a thickest tree that grows well in the city named c (which is in Maine). The output should be sorted by non-increasing thickness and then (secondary sort) ascending order of city names.

4. (6 pts.) Write an extended bag algebra query that is equivalent to the SQL query of Question 3a.

5. (10 pts) ⋆ Refer to the query in your answer to Question 3b. If that query uses a subquery then provide here an equivalent query that does not use subqueries (has only one select clause). If that query uses a group-by clause then provide here an equivalent query that does not use a group-by clause.

Trees

name	botname	ttype	dia	height	minz	maxz
varchar(50)	varchar(50)	varchar(25)	float	float	int	int
White Pine	Pinus strobus	coniferous	30.0	90.0	3	8
Pitch Pine	Pinus rigida	coniferous	18.0	35.0	5	7
Bigtooth Aspen	Populus grandidentata	deciduous	15.0	70.0	3	5
Quaking Aspen	Populus tremuloides	deciduous	13.0	67.5	1	8

Places

city	state	pop	zone	subzone	mintemp
varchar(20)	varchar(20)	integer	integer	char(1)	float
Orono	Maine	9112	5	b	-15.0
Bangor	Maine	31473	5	a	-15.1
Bar Harbor	Maine	4820	5	b	-14.0
Caribou	Maine	8312	4	a	-25.4
Van Buren	Maine	2631	3	a	-35.6
Tucson	Arizona	486699	8	a	39.0

For notational convenience in relational algebra, we shall abbreviate as follows:

Trees(name, botname, ttype, dia, height, minz, maxz) $T(N, B, T, D, H, M, X)$
Places(city, state, pop, zone, subzone, mintemp) $P(C, S, P, Z, Y, L)$

Figure 1: A tree database.