By providing my signature below I acknowledge that I abide by the University's academic honesty policy. This is my work, and I did not get any help from anyone else during the exam:

Name (sign): _____ Name (print): _____

Student Number: _____

Instructor's Name: _____ Class Time: _____

Problem Number	Points Possible	Points Made
1	0	
2	15	
3	15	
4	20	
5	20	
6	15	
7	15	
Total:	100	

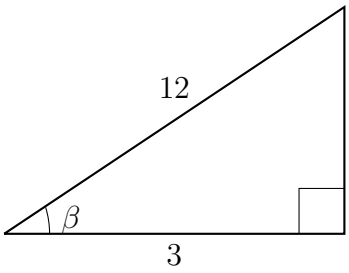
- If you need extra space use the last page.
- Please show your work. **An unjustified answer may receive little or no credit.**
- If you make use of a theorem to justify a conclusion then state the theorem used by name.
- Your work must be **neat**. If I can't read it (or can't find it), I can't grade it.
- The total number of possible points that is assigned for each problem is shown here. The number of points for each subproblem is shown within the exam.
- Please turn off your mobile phone.
- A calculator is not necessary, but numerical answers should be given in a form that can be directly entered into a calculator.
- Common identities:

$$\begin{aligned}\cos(\alpha+\beta) &= \cos(\alpha)\cos(\beta)-\sin(\alpha)\sin(\beta),\\ \sin(\alpha+\beta) &= \sin(\alpha)\cos(\beta)+\cos(\alpha)\sin(\beta).\end{aligned}$$

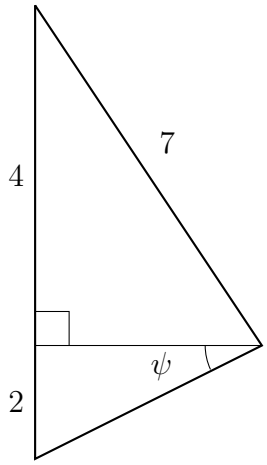
1. [2 Bonus] Common Knowledge: Is it wise to have Tadej Pogačar ride Paris-Roubaix?

2. Determine the values of the requested quantities in each question below. All values should be either exact or within 0.01 of the true value. (**All angles are given in radians and should be expressed in radians if you have to determine their value**.)

   (a) [5 pts] Determine the sine, cosine, and tangent of the angle β in the diagram below.

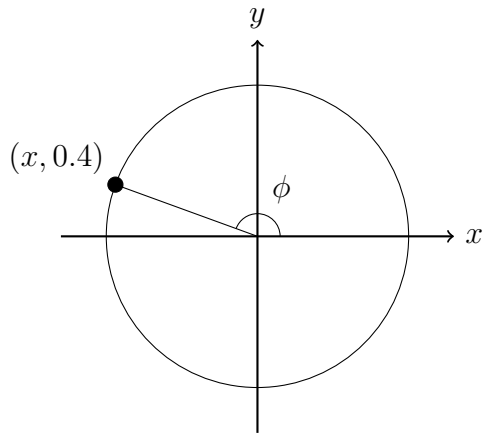


   (b) [10 pts] Determine the exact numerical values of the sine, cosine, and tangent of the angle ψ in the diagram below.

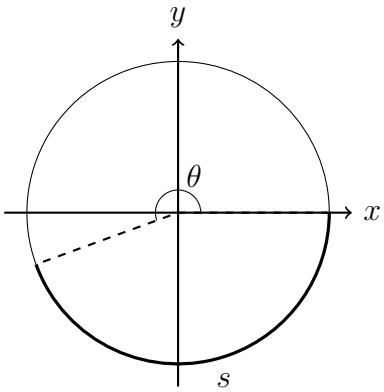


3. Determine the values of the requested quantities in each question below. All values should be either exact or within 0.01 of the true value unless otherwise stated. (**All angles are given in radians and should be expressed in radians if you have to determine their value**.)

   (a) [5 pts] A unit circle is shown in the diagram below. Determine the values of the cosine, sine, and tangent of the angle ϕ. (Provide an exact answer.)



   (b) [5 pts] The circle in the diagram below has a radius of two units. The angle, θ, is 3.9 radians. Determine the value of the arclength, s, as shown in the diagram.



   (c) [5 pts] Determine the angle in the third quadrant that has a reference angle of $\frac{\pi}{5}$ radians.

4. Determine the exact value of the following expressions. Your final answer should not include a trigonometric function. Show you work and leave your answer as an exact expression and not a numerical approximation from a calculator. Do not just write an answer but show each step and provide a brief justification when a function is evaluated.

   (a) [10 pts] $\tan\left(\arccos\left(\frac{5}{7}\right)\right)$

   (b) [10 pts] $\arccos\left(\cos\left(\frac{9\pi}{8}\right)\right)$.

5. Answer each question below. For each question the angles should be in radians and be in the interval $[0, 2\pi)$.

   (a) [5 pts] In which quadrants is the sine increasing?

   (b) [5 pts] For which angles is the sine increasing? (Your answer should be in radians, use interval notation, and be in the interval $[0, 2\pi)$.

   (c) [5 pts] In which quadrants is the cosine decreasing?

   (d) [5 pts] For which angles is the cosine decreasing? (Your answer should be in radians, use interval notation, and be in the interval $[0, 2\pi)$.

6. [15 pts] The displacement of one of the vibrating wires in a piano is

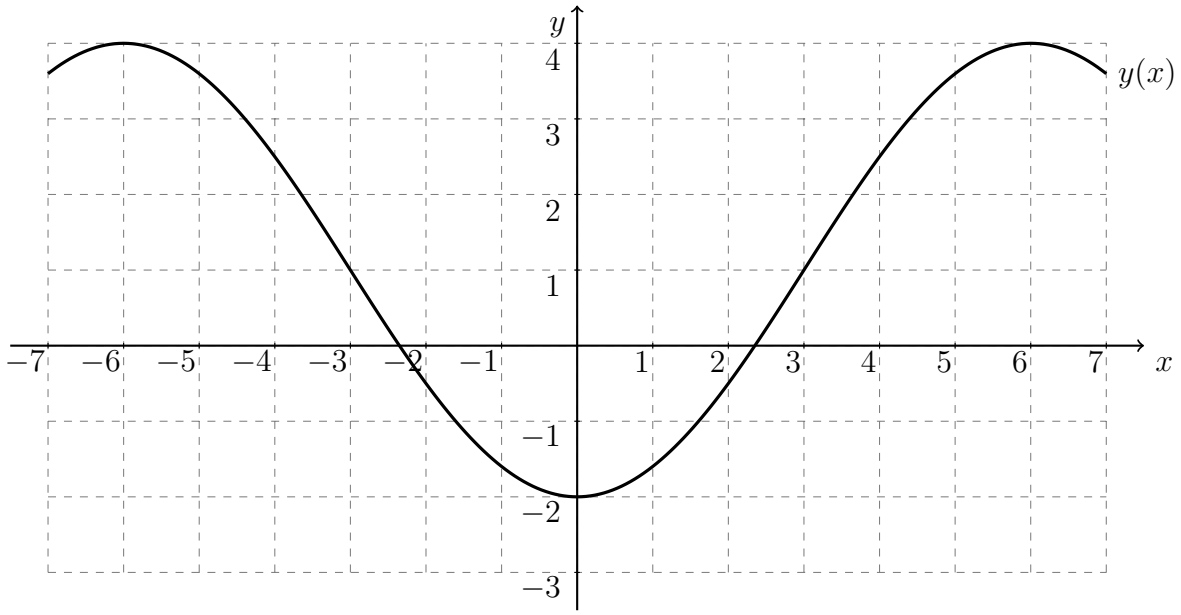
$$D(t) = 0.05\cos\left(0.1\frac{\sqrt{T}}{L}t\right),$$

where T is the tension in the wire (measured in Newtons), L is the length of the wire (meters), and t is the time. A piano maker wishes to make a wire that vibrates 500 cycles per second, and the length of the wire will be 0.9 meters. What tension will be required?

7. [15 pts] Express the function whose graph is shown below as a cosine function,

$$y(x) \;=\; A\sin(Bx + C) + D,$$

where $A > 0$ and $B > 0$.



A=

B=

C=

D=

Extra space for work. **Do not detach this page.** If you want us to consider the work on this page you should print your name, instructor and class meeting time below.

Name (print): _____ Instructor (print): _____ Time: _____