$(\neg(\neg\phi_1 \vee \phi_2)$

$(\phi_1 \wedge \neg\phi_2)$

Final

Introduction to Computational Logic — Fall 2024

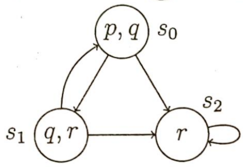
(1) Please select the topics you like in the class (multiple choices): (20%)

(A) propositional logic (B) predicate logic (C) program verification (D) model checking

(2) Recall that a logic formula is in *negation normal form* if negations ($\neg$) only occur before propositional atoms. Show that every LTL formula ϕ has a semantically equivalent formula ψ in negation normal form. (20%)

(3) Consider the LTL formula $\phi \triangleq \neg(a \, \mathbf{U} \, \neg b)$. Construct a transition system A_ϕ that accepts exactly the traces satisfying ϕ. $C(\phi) = \{a, \neg a, b, \neg b, a \, U \neg b, \neg(a \, U \neg b)\}$ (20%)

(4) Consider the following transition system $\mathcal{M} = (S, \rightarrow, L)$:



Compute the following sets:

(a) $\{s \in S : \mathcal{M}, s \models \mathbf{EF}(q \wedge r)\}$; $s_0 \quad s_1$

(b) $\{s \in S : \mathcal{M}, s \models \mathbf{EG}r\}$. $s_1 \quad s_2$

(20%)

(5) Consider the following program E:

```
z = 0
while (y != 0) {
    if (y mod 2 == 1) {
        z = z + x
        y = (y - 1)/2
    } else {
        y = y / 2
    }
    x = x + x
}
```

$\Rightarrow x = 2x$

$\Rightarrow y = 0$

Show $\vdash_{\text{par}} (\!| x = x_0 \wedge y = y_0 \geq 0 |\!) \, E \, (\!| z = x_0 \times y_0 |\!)$. (20%)

$z + x \times y = x_0 \times y_0$

y odd — y even

$(z + x) + (2x) \cdot \frac{y-1}{2}$ $\qquad$ $z + (2x) \cdot \left(\frac{y}{2}\right)$