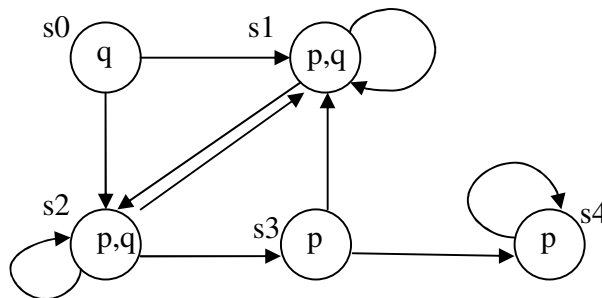


1. **[1,5 points]** Show that the following pairs of LTL formulas are not equivalent by giving a path that satisfies one of them but does not satisfy the other:
  - a)  $FG p$  and  $G(p \Rightarrow X p)$
  - b)  $FG p$  and  $\neg p U Gp$
  - c)  $G(p \Rightarrow X p)$  and  $\neg p U Gp$ .
  
2. **[1,5 points]** Find a transition system  $M$  and a state  $s$  which distinguishes the following pairs of CTL formulas, showing thus that they are not equivalent:
  - a)  $EF p$  and  $EG p$
  - b)  $AF(p \vee q)$  and  $AF p \vee AF q$
  - c)  $EF \neg p$  and  $\neg AF p$
  
3. **[2 points]** Using the *labelling algorithm*, determine for each state of the following transition system whether or not the CTL formula  $E[(p \vee \neg q) U E[\neg q U AGp]]$  holds:



4. **[2 points]** Give a derivation for calculating the final state  $\sigma'$  of the following command

if  $x > 0$  then  $x := x + y$  else  $x := x - y$  fi

when starting from an initial state  $\sigma$  with  $\sigma(x) = 2$  and  $\sigma(y) = 0$ .

5. **[1 point]** Calculate the weakest precondition  $P$  of the following command

$\{ P \}$  if  $x > 0$  then  $x := x + y$  else  $x := x - y$  fi  $\{ x \geq y \}$

6. **[2 points]** Give a proof outline for the *total* correctness of the following Hoare triple:

```

{ k ≥ 0 }
i := k;
x := 1;
while i ≠ 0 do
  i := i - 1;
  x := 2 * x
od
{ x = 2k }
  
```

The final score is given by the sum of the points obtained.