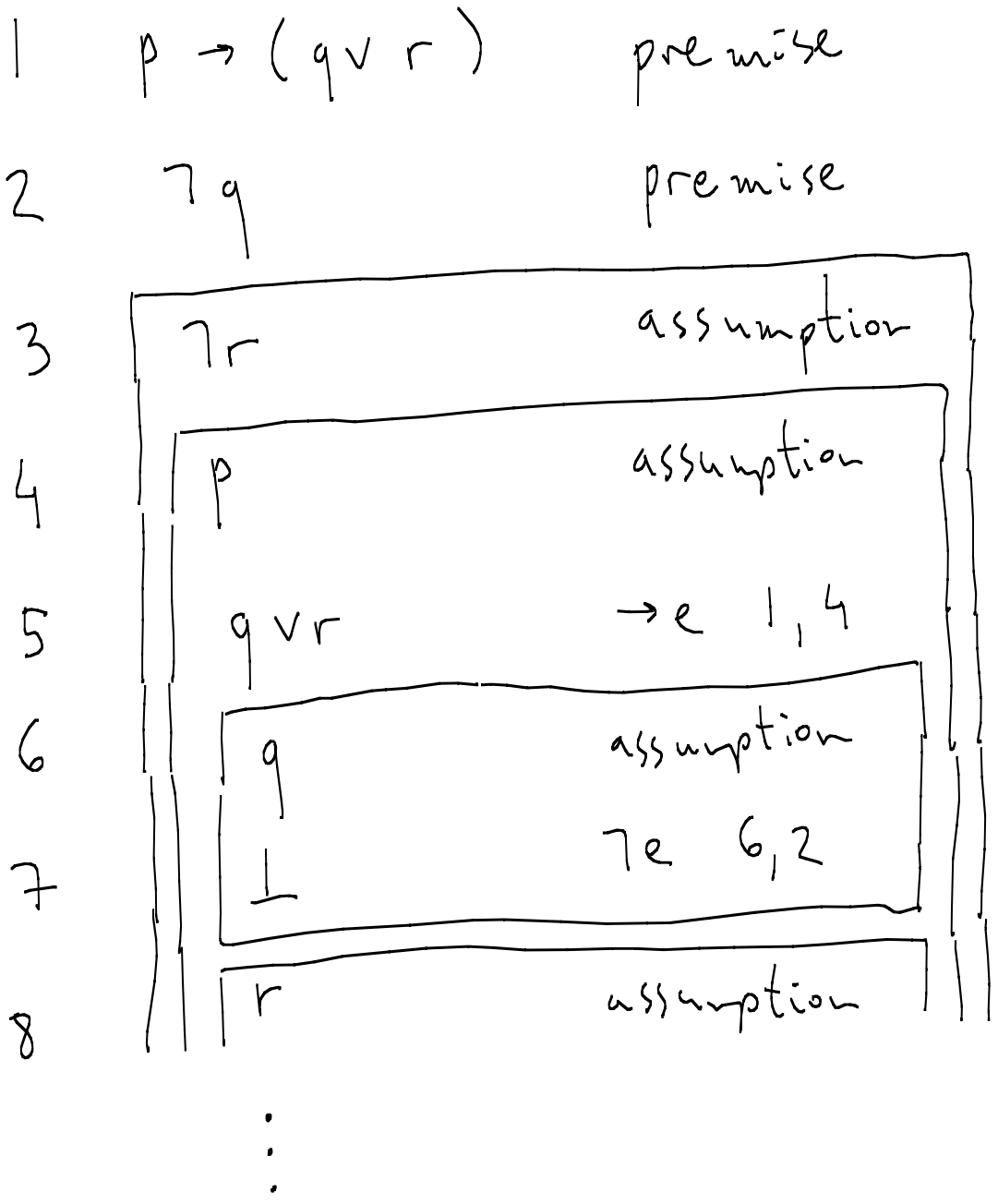
1. (b)


1 p → (q v r) premise
2 ¬q premise
3 ¬r assumption
4 p assumption
5 q v r →e 1, 4
6 q assumption
7 ⊥ ¬e 6, 2
8 r assumption
⋮

¬r → ¬p

¬p

⊥

2. (c)

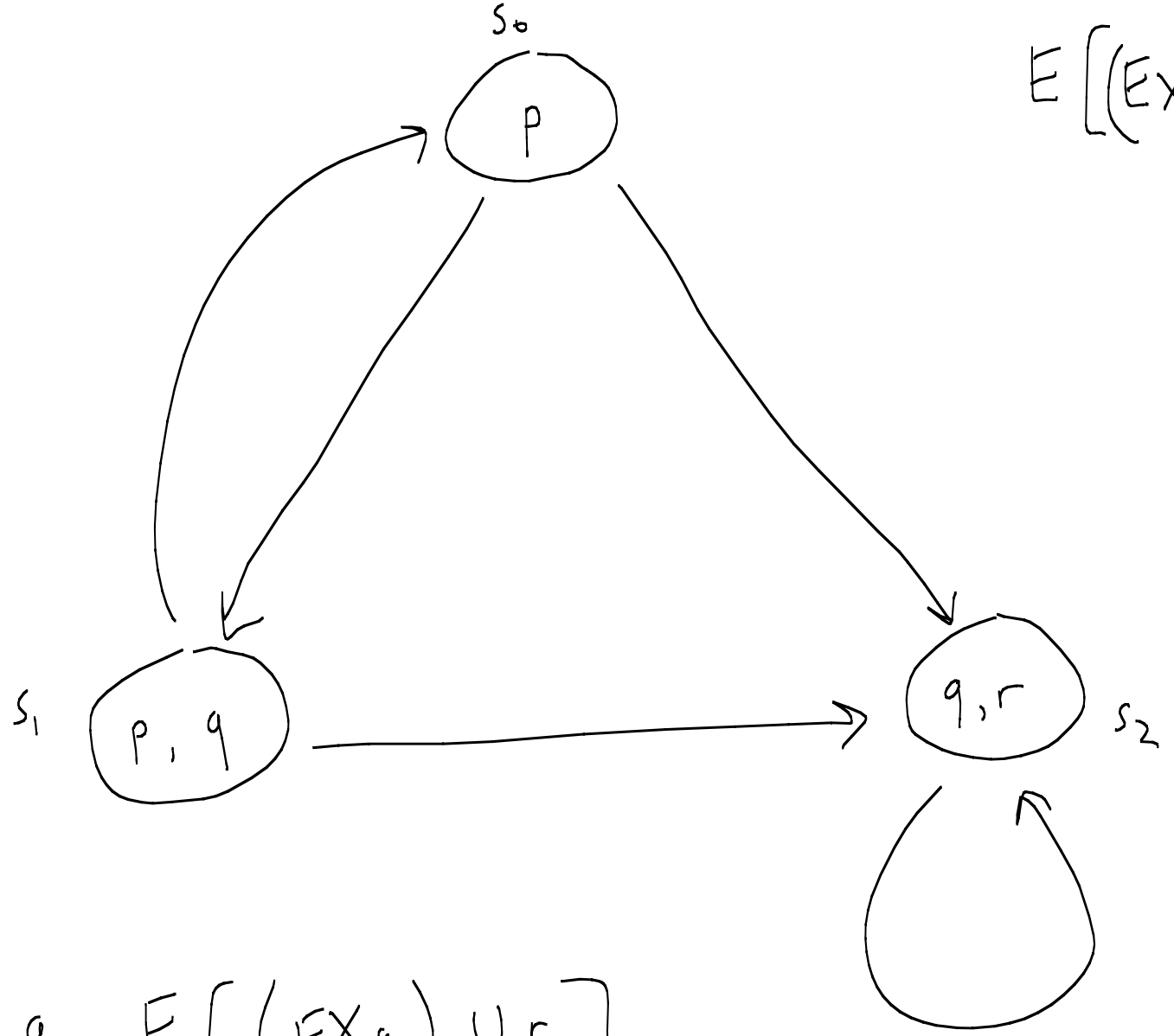
$$f^{M}(a) = a$$

$$f^{M}(b) = b$$

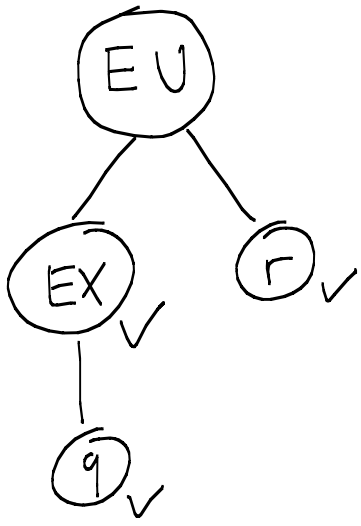
$$f^{M}(c) = c$$

$$f^{M}(d) = d$$

3. (a)




$E[(EX\ q)\ U\ r]$




$EX\ q,\ E[(EX\ q)\ U\ r]$

4. (c)

$(\!| x_0 = x \wedge x \geq 0 |\!)$

$(\!| x_0 = y \cdot 0 + x \wedge x \geq 0 |\!)$ Implied

```
z = 0;
```

$(\!| x_0 = y \cdot z + x \wedge x \geq 0 |\!)$ Assignment

```
while (x >= y) {
```

$(\!| x_0 = y \cdot z + x \wedge x \geq 0 \wedge x \geq y |\!)$ Inv.Hyp. $\wedge$ guard

$(\!| x_0 = y \cdot (z+1) + x - y \wedge x - y \geq 0 |\!)$ Implied

```
    z = z + 1;
```

$(\!| x_0 = y \cdot z + x - y \wedge x - y \geq 0 |\!)$ Assignment

```
    x = x - y;
```

$(\!| x_0 = y \cdot z + x \wedge x \geq 0 |\!)$ Assignment

```
}
```

$(\!| x_0 = y \cdot z + x \wedge x < y \wedge x \geq 0 |\!)$ Partial-while