1. Given,

Length of solenoid = 0.20 m

Radius of solenoid = 0.045 m

Number of turns = 350

Radius of conducting loop = 0.030 m

Resistance of the loop = 7 mΩ

a) Given,

Rate of decrease in current flow = 18 A/s

$$\frac{dI}{dt} = -18\ A/s$$

As per Faraday's law,

Induced EMF,

$$\varepsilon = \mu_0 \frac{\Delta I}{\Delta t} \frac{N}{L} = 4\,\pi * 10^{-7} * -18 * \frac{350}{0.20}$$

$$\varepsilon = -395640 * 10^{-7} = -0.0395\ V$$

$$\varepsilon = I * R$$

$$I = \frac{\varepsilon}{R} = \frac{0.0395}{7} = 0.0056\ A$$

Therefore current in single loop = $5.6 * 10^{-3}$ A

The induced current will be flowing in anti clockwise direction since it will be flowing opposite to the magnetic flux inside the solenoid.

b) The magnitude of the magnetic field is given by,

$$B = \frac{\mu_0 I}{2 \pi r} = \frac{4 \pi * 10^{-7} * 2.57}{2 \pi * 0.030} = 171.33 * 10^{-7} T$$

Since the current is flowing away from the loop, the magnetic field will be in counter clockwise direction.

c) Resistance = 12 mΩ

Assuming the current is decreasing at a rate of 18 A as mentioned in part a,

$$\varepsilon = -N \frac{\Delta I}{\Delta t} = -1 * -18 = 18$$

$$I = \frac{\varepsilon}{R} = \frac{18}{12} = 1.5 A$$

As per part (a), current in larger loop is 1.974 A (0.0056 * 350).

Therefore, the value of induced emf should be,

$$\varepsilon = 1.974 * 12 = 23.688 V$$

Substituting,

$$\varepsilon = -N \frac{\Delta I}{\Delta t} = 23.688$$

$$\frac{\Delta I}{\Delta t} = 23.688 , Since\ N = 1$$

$$\Delta t = \frac{\Delta I}{23.688} = \frac{1.5}{23.688} = 6.33 * 10^{-2}\ seconds$$

2. Given,

Mass of the metal rod = 1.5 kg

Distance between the wires = 0.85 m

Resistance = 3.5 Ω

Strength of magnetic field = 2.0 T

a) The magnitude of the current can be found from the below equation,

F = I * 0.85 * 2

$$v^2 = v_0^2 + 2\ a\ S$$

$$9 = 0 + 2 * a * 0.85$$

1.7 a = 9

a = 5.29 m/s^2

The acceleration will be moving in positive downward direction.

F = m * a

F = 1.5 * 5.29 = 7.935

Substituting,

7.935 = 1.7 I

I = 4.66 A

The direction of the current will be in clockwise direction.

b) Velocity = 15 m/s

$v^2 = v_0^2 + 2\, a\, S$

225 = 0 + 2 * a * 0.85

1.7 a = 225

a = 132.35 m/s^2

The direction of the acceleration will be in positive downward direction.

c) The terminal velocity is given by,

$$v = \frac{MgR}{B^2 w^2} = \frac{1.5 * 9.8 * 3.5}{4 * 0.7225} = \frac{51.45}{2.89} = 17.80\ m/s$$