20-P-MOM-JK-420 Impact similar to F15-7 on page 261 of the 14th edition

Two railroad freight cars collide and then separate.
What is the average impulsive force that acts between them?

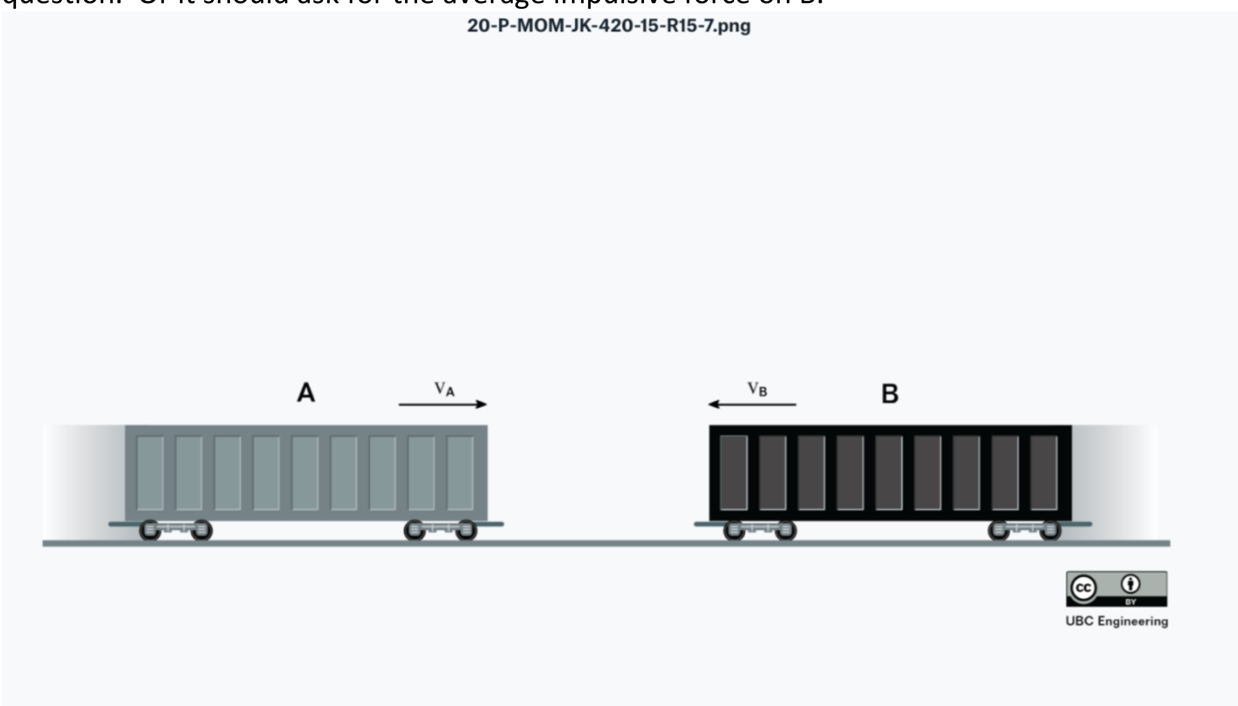
Freight car A has a mass of 20 Mg = 20 x 10^3 kg
Freight car B has a mass of 15 Mg = 15 x 10^3 kg

The initial velocity of A was vA = 3.0 m/s to the right
The initial velocity of B was vB = 1.5 m/s to the left
As shown in the diagram.

The cars collide and rebound, such that after the collision B moves to the right with a speed of 2 m/s.

A and B were in contact for t = 0.5 seconds.

a) final velocity of freight car A?
b)What is the average impulsive force that acts between them?
Note: should ask for MAGNITUDE due to Newton's third law, but that is implicit in the question. Or it should ask for the average impulsive force on B.



Answer. Momentum is conserved, because it is the law.

To the right is positive. → +

$mA\ (vA)_{before} + mB\ (vB)_{before} = mA\ (vA)_{after} + mB\ (vB)_{after}$
or
$mA\ (vA)_1 + mB\ (vB)_1 = mA\ (vA)_2 + mB\ (vB)_2$

Freight car A has a mass of 20 Mg = 20 x 10^3 kg
Freight car B has a mass of 15 Mg = 15 x 10^3 kg

$(20 \times 10^3\ kg)(+\ 3.0\ m/s)\ +\ (15 \times 10^3\ kg\ )(-\ 1.50\ m/s)$
$\quad = (20 \times 10^3\ kg\ )(vA)_2 + (20)\ (15 \times 10^3\ kg)\ (+2.0\ m/s)$

$(vA)_2 = (vA)_{after} = +\ 0.375$ m/s or 0.375 m/s to the right

**** now for the magnitude of the average force ****

To the right is positive. → +

$$mB\ (vB)_1 + \Sigma \int_{t1}^{t2} F\ dt = mB\ (vB)_2$$

$(15 \times 10^3\ kg)\ (\ -\ 1.5\ m/s) + F_{average}\ (0.5\ s) = (15 \times 10^3\ kg)\ (\ +\ 2.0\ m/s)$

F average = 105 x 10^3 N = 105 kN

Personally I think of impulse as

$F_{average} = \Delta p\ /\Delta t = mB\ \ (\ (vB)2 - (vB)1\ )\ /\ (\Delta t)$

$F_{average} = \Delta p\ /\Delta t = (15 \times 10^3\ kg)\ \ (\ +2.00 - (-1.5\ m/s)\ )\ /\ (0.5\ s) = 105\ kN$

For the coding

mA between 70,000 and 99,000 kg
mB between 40,000 and 60,000 kg

Source:
https://www.csx.com/index.cfm/customers/resources/equipment/railroad-equipment/
freight capacity is between 70-100 tons or 70,000 kg and 100,000 kg

The initial velocity of A vA = + to the right, and between 3.00 and 5.00 m/s
The initial velocity of B was vB = - to the left, and between 1.5 and 2.50 m/s.
As shown in the diagram. vB maximum must be less than vA minimum

The cars collide and rebound, such that after the collision B moves to the right with a speed
vB 2 = vB after = + to the right, and between 2.50 and 3.00 m/s

A and B were in contact for t seconds of between 0.2 and 0.5 seconds.

a) $mA\ (vA)_{before} + mB\ (vB)_{before} = mA\ (vA)_{after} + mB\ (vB)_{after}$
or
$mA\ (vA)_1 + mB\ (vB)_1 = mA\ (vA)_2 + mB\ (vB)_2$

$$(vA)_{after} = \frac{mA\ (vA)_{before} + mB\ (vB)_{before} - mB\ (vB)_{after}}{mA}$$

or as the textbook uses 1 for before and 2 for after the collision

$$(vA)_2 = \frac{mA\ (vA)_2 + mB\ (vB)_2 - mB\ (vB)_1}{mA}$$

b) $F_{average} = \Delta p / \Delta t = mB\ (\ (vB)_{after} - (vB)_{before}\ )\ /\ (\Delta t)$

or as the textbook uses 1 for before and 2 for after the collision

$F_{average} = \Delta p / \Delta t = mB\ (\ (vB)_2 - (vB)_1\ )\ /\ (\Delta t)$