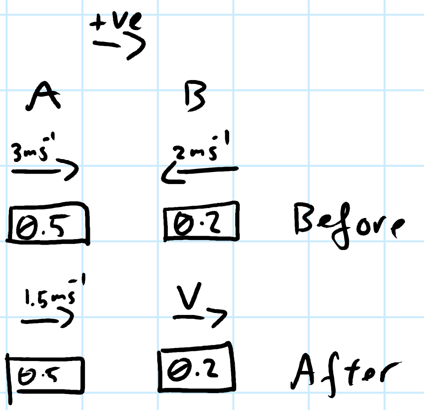
June 2001 MA - M1

1)

a)



Conservation of momentum:

$$3\times0.5 + -2\times0.2 = 1.5\times0.5 + V\times0.2$$

$$1.1 = 0.75 + 0.2V$$

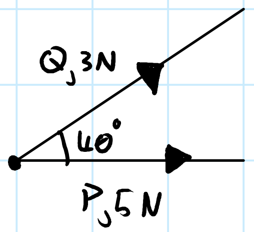
$$V = 1.75 \text{ ms}^{-1}$$

Remember, the question asked for speed ignore signs.

b) $\Delta P = [1.75 - -2]\times0.2$

$= 0.75 \text{ Ns}$

2)



Resolve Horizontally:

$5\cos(0°) + 3\cos(40°) = 7.30\,N$

Resolve Vertically:

$5\sin(0°) + 3\sin(40°) = 1.93\,N$

a) Magnitude of F

$|F| = \sqrt{F(\uparrow)^2 + F(\rightarrow)^2}$

$= \sqrt{7.3^2 + 1.9^2}$

$= 7.55$ (3sf)

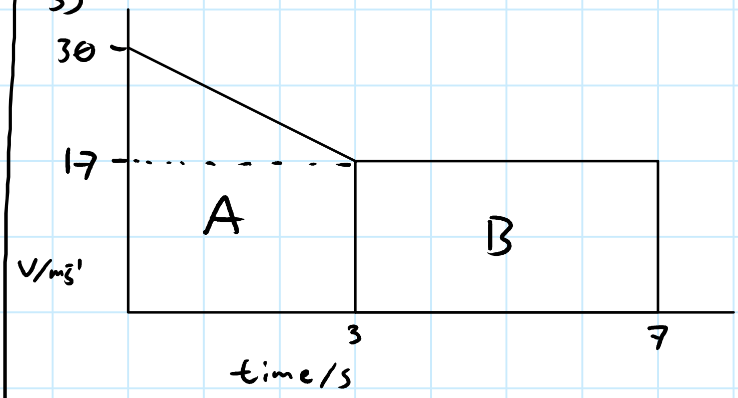
b) argument (direction) of F

$\arg(F) = \tan^{-1}\left(\frac{F(\uparrow)}{F(\rightarrow)}\right)$

$= \tan^{-1}\left(\frac{1.9}{7.3}\right)$

$= 14.8°$ (1dp)

3)



a)

Distance is total area under a speed/time graph

Area of trapezium A:

$\frac{1}{2}(17+30)\times 3 = 70.5\text{ m}$

Area of rectangle B:

$(7-3)\times 17 = 68\text{ m}$

$70.5 + 68 = 138.5\text{ m}$

b) Mass is constant, therefore Force α acceleration

Straight line on a speed time graph shows constant acceleration

If m & a are constant, and F = ma

F is therefore constant.

3)

c) $\frac{\Delta \text{Speed}}{\Delta \text{time}} = \frac{17-30}{3-0}$

$= -\frac{13}{3}$

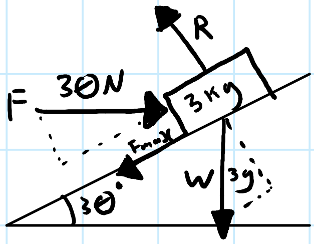
$F = ma \quad \therefore \quad F = 1200 \times -\frac{13}{3}$

$F = -5200$

$|F| = 5200$

4)

a)



F_{max} acts against any motion. Since the parcel is about to move *up* the plane, F_{max} acts *down* the plane.

b)

Resolving F (↘) :

$30\sin(30°) = 15\ N$

Resolving W (↘)

$3g\cos(30°) = 3g\frac{\sqrt{3}}{2}$

$= 25.5\ N$

$15 + 25.5 = 40.5\ N$ (3 sf)

4)

c) Resolving Forces ($\nearrow$) up the plane

$F_{max}(\nearrow) = -F_{max}\,N$

$W(\nearrow) = -3g\sin(30)$

$= -14.7N$

$F(\nearrow) = 30\cos(30)$

$= 26.0N$

$R(\nearrow) = 0$

Forces in equilibrium

$26.0 + 0 - 14.7 - F_{max} = 0$

$F_{max} = 11.3N$

$= \mu|R|$

from (b) $|R| = 40.5$

$\therefore \mu = \frac{11.3}{40.5}$

$= 0.279$ (3 s f)

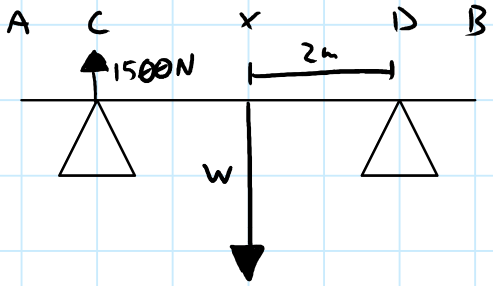
5)

a) $0 N$

b)

Uniform

$\therefore CX = XD = 2m$



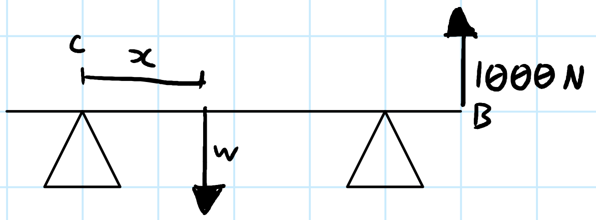
Principle of moments

$2W = (6-1) \times 1500$

$W = 3750N$

5)

c)



Principle of moments

$xw = 5 \times 1000$

& From (b):

$(4-x)w = 5 \times 1500$

$4w - xw = 7500$

$4w - xw + xw = 7500 + 5000$

$4w = 12{,}500$

$w = 3{,}125\ N$

d) from (c)

$3{,}125x = 5000\ N$

$x = \frac{5}{8}$

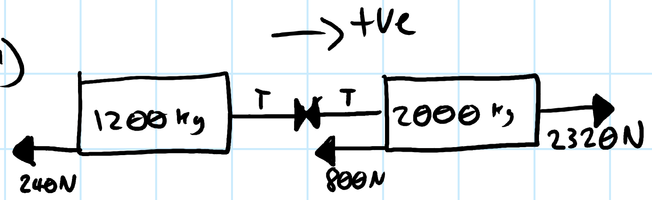
$= 1.6$

e) AB remains a straight line at all times when forces are applied at either end.

A string would have flexed under force and not remained straight

6)

a)



$F_{(Resultant)} = m_T a$

$2320 - 800 - 240 = (2000 + 1200) a$

$1280 = 3200 a$

$a = 0.4 ms^{-1}$

b) car:

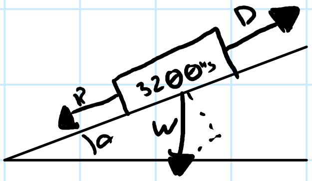
$T - 240 = 1200 \times 0.4$

$T = 480 + 240$

$T = 720 N$

6)

c)



$\sin(a) = \frac{1}{20}$

Model the system as 1 particle with 1 driving force and 1 combined resistance

$W(\swarrow) = 3200g \times \sin(a)$

$= 1568 N$

$2320 - 1568 - 800 - 240 = -288 N$

$F = ma$

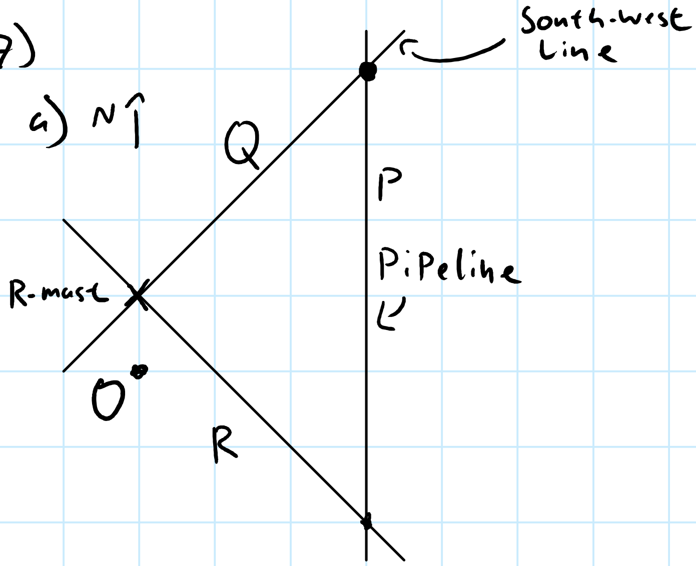
$a = \frac{-288}{3200}$

$= -0.09 ms^{-2}$

answer: $0.09 ms^{-2}$, Speed decreasing

7)

a)



Line P follows the pipeline
Line Q goes through the radio mast and travels south east

$$P = (6i + 0j) + \lambda(0i + j)$$
$$Q = (0i + 2j) + \mu(-i - j)$$

walker where $P = Q$

$$6i + \lambda j = 2j - \mu i - \mu j$$

$$6 = -\mu \quad \therefore \quad \mu = -6$$
$$\lambda = 2 - \mu \qquad \lambda = 8$$

walker at $2j - 6(-i - j)$

$$(6i + 8j)$$

7)

b) $8^2 + 6^2 = 10^2$

$$\frac{10\text{ km}}{5\text{ km h}^{-1}} = 2\text{ h}$$

c) Line R goes through the radio mast and travels north-west

$R = (0i + 2j) + \nu(-i + j)$

walker found where $P = R$

$6i + \lambda j = 2j - \nu i + \nu j$

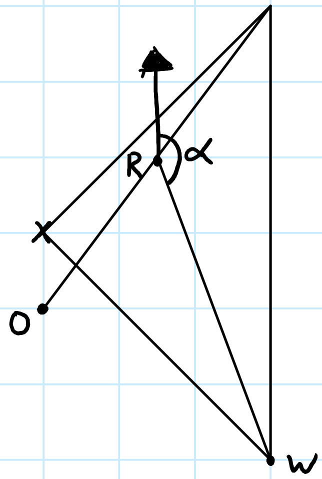
$6 = -\nu \quad \therefore \quad \nu = -6$

$\lambda = 2 + \nu \qquad \lambda = -4$

walker at $6i - 4j$

7

d)

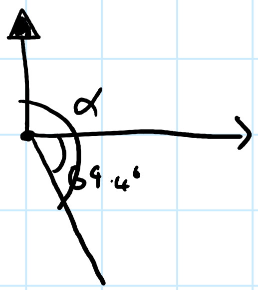


If the rescue party have travelled half the distance towards intersect of P and Q (position vector 6i + 8j) then they travelled to R (position vector 3i + 4j)
Walker is at intersect of P and R (position vector 6i - 4j) labelled W

$$\overrightarrow{RW} = (6i - 4j) - (3i + 4j)$$
$$= 3i - 8j$$

gradient of $\overrightarrow{RW}$ is

$$\tan^{-1}\left(\frac{-8}{3}\right)$$
$$-69.4°$$



$$\alpha = 90 + 69.4°$$
$$= 159.4°$$