Year 12 Full AS Mechanics
Internal Mock Dec 2022
Labelling as Year 12 Full AS Mock Set#02b

Topic List

- Mechanics (Full AS) (30 marks)

Section B: Mechanics

1.

Two trams, tram A and tram B, run on parallel straight horizontal tracks. Initially the two trams are at rest in the depot and level with each other. The trams are modelled as particles.

- At time $t = 0$, tram A starts to move. Tram A moves with constant acceleration 2 ms^{-2} for 5 seconds and then continues to move along the track at constant speed.
- At time $t = 20$ seconds, tram B starts from rest and moves in the same direction as tram A. Tram B moves with constant acceleration 3 ms^{-2} for 4 seconds and then continues to move along the track at constant speed.

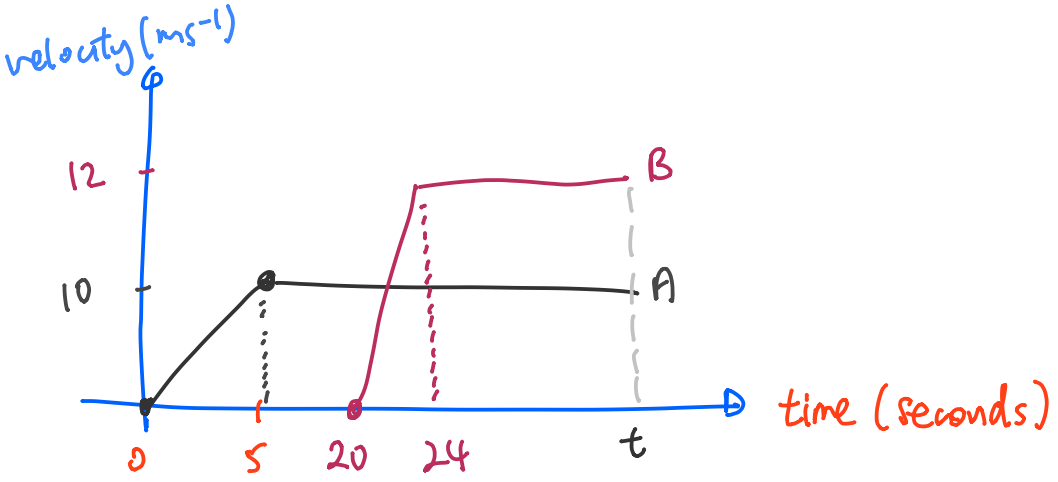
(a) Sketch, on the same axes, a speed-time graph for the motion of tram A and a speed-time graph for the motion of tram B, from $t = 0$ to the instant when tram B overtakes tram A.

(3)

(b) Find the distance of the trams from the depot at the instant when tram B overtakes tram A.

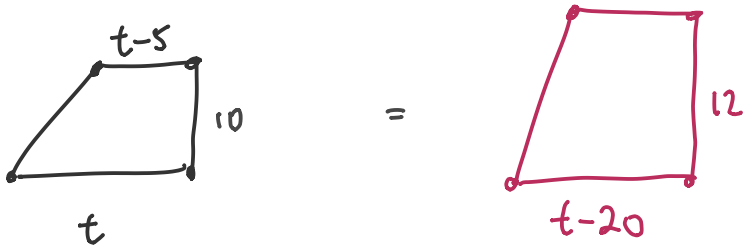
(5)

a)



b)

Area is the same



$$\frac{[(t-5)+(t)]10}{2} = \frac{[(t-24)+(t-20)]12}{2}$$

$$10(2t-5) = 12(2t-44)$$

$$10t-25 = 12t-264$$

$t = 119.5$

distance $= \frac{(t-5+t)(10)}{2}$

$= 1170\text{m}$ //

2.

A fixed point O lies on a straight line. A particle P moves along the straight line. At time t seconds, $t \geq 0$, the distance s metres, of P from O is given by

$$s = \frac{1}{3}t^3 - \frac{5}{2}t^2 + 6t$$

(a) Find the acceleration of P at each of the times when P is at instantaneous rest. **(6)**

(b) Find the total distance travelled by P in the interval $0 \leq t \leq 4$ **(3)**

a) $\frac{d}{dt}s = v = t^2 - 5t + 6$ ⇒ instantaneous rest ⇒ $v = 0$

$t^2 - 5t + 6 = 0$

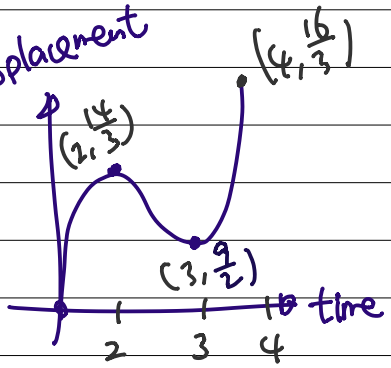
$t = 2$ or $t = 3$

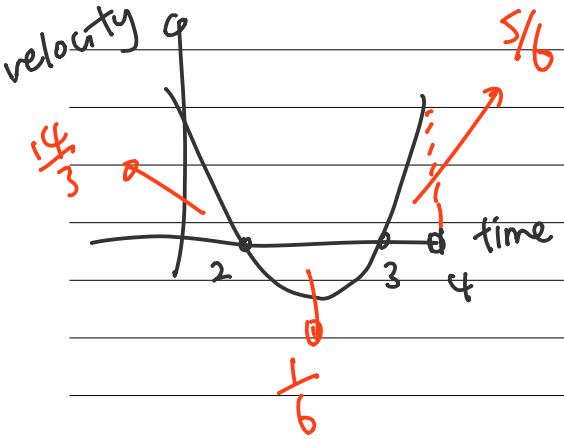
⇒ acceleration = -1 or 1 ms^{-2} //

$\frac{dv}{dt} = a = 2t - 5$

$\frac{d^2x}{dt^2} < 0$ max $\qquad$ $\frac{d^2x}{dt^2} > 0$ min

b)





0 to 2 ⟶ forward $(\frac{14}{3})$

2 to 3 ⟵ backward $(\frac{1}{6})$

3 to 4 ⟶ forward $(\frac{5}{6})$

you can $\int t^2 - 5t + 6\, dt$

or just sub into $s = \frac{t^3}{3} - \frac{5}{2}t^2 + 6t$

⇒ distance = $\frac{14}{3} - \frac{1}{6} + \frac{5}{6} = \frac{16}{3}$ //

3.

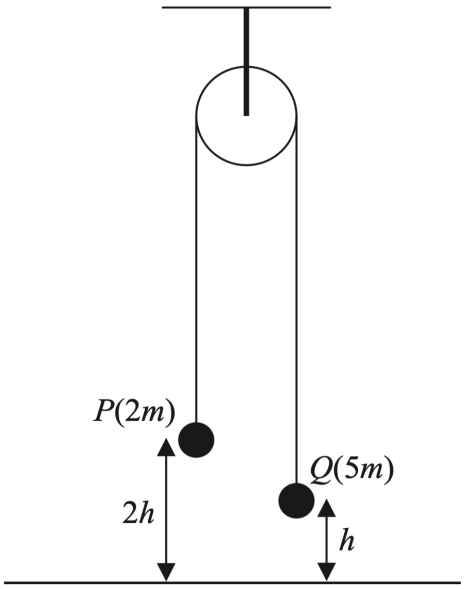


Figure 1

A ball P of mass $2m$ is attached to one end of a string.

The other end of the string is attached to a ball Q of mass $5m$.

The string passes over a fixed pulley.

The system is held at rest with the balls hanging freely and the string taut.

The hanging parts of the string are vertical with P at a height $2h$ above horizontal ground and with Q at a height h above the ground, as shown in Figure 1.

The system is released from rest.

In the subsequent motion, Q does not rebound when it hits the ground and P does not hit the pulley.

The balls are modelled as particles.

The string is modelled as being light and inextensible.

The pulley is modelled as being small and smooth.

Air resistance is modelled as being negligible.

Using this model,

(a) (i) write down an equation of motion for P,
(ii) write down an equation of motion for Q.

(4)

(b) Find, in terms of h only, the height above the ground at which P first comes to instantaneous rest.

(7)

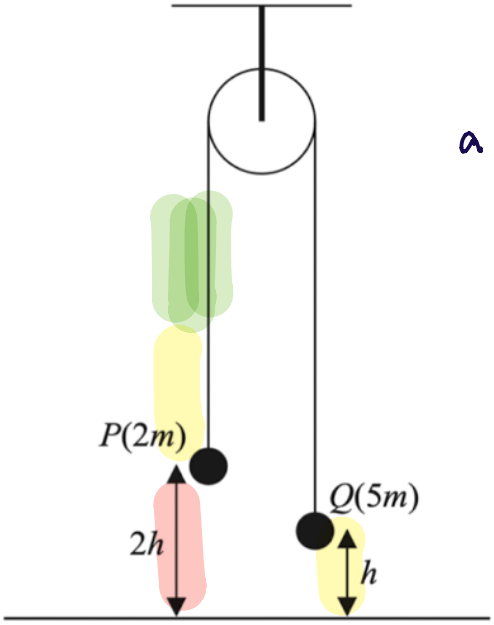
(c) State one limitation of modelling the balls as particles that could affect your answer to part (b).

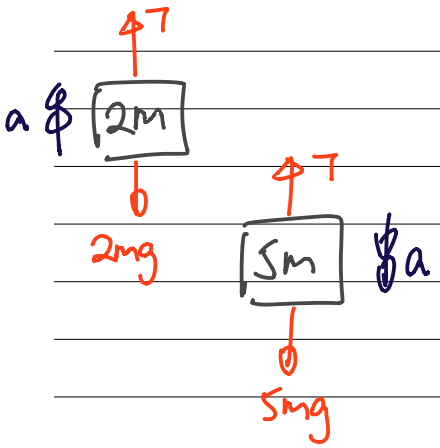
(1)

In reality, the string will not be inextensible.

(d) State how this would affect the accelerations of the particles.

(1)





(2m):
$T - 2mg = 2ma$ -①

(5m):
$5mg - T = 5ma$ -②

①+②: $3mg = 7ma$

$a = \frac{3g}{7}$

sub into ①:

$T - 2mg = 2m(\frac{3g}{7})$

$T = \frac{6mg}{7} + 2mg$

$T = \frac{20mg}{7}$ //

Stage 1

b) $v^2 - u^2 = 2as$

$v = ?$ $u = 0$ $a = \frac{3g}{7}$ $s = h$

$v^2 = 2(\frac{3g}{7})(h)$

$v = \sqrt{\frac{6gh}{7}}$

$\frac{3gh}{7}$ (Stage 2)

h (stage 1)

$2h$ (initial)

Stage 2 (subsegrent motion)

$v = 0$ $u = \sqrt{\frac{6gh}{7}}$ $a = -g$ $s = ?$

$v^2 - u^2 = 2as$

$-\frac{6gh}{7} = -2gs$

$s = \frac{3h}{7}$

height $= 2h + h + \frac{3gh}{7}$

$= \frac{24h}{7}$ //

↑ T=0

2m

↓ 2mg

"F = ma"

2mg = 2m a

g = a

stage 2 is "free-falling" or gravity slowing the upward motion down

(c) State one limitation of modelling the balls as particles that could affect your answer to part (b).

(1)

In reality, the string will not be inextensible.

(d) State how this would affect the accelerations of the particles.

(1)

c) size of the ball / spin of the ball

d) ↑ a

↓ a

acceleration won't have the same magnitude