Mock Exam 2

MATHEMATICS **9709**

Paper 4 Mechanics 1 **(M1)** **1 hour 15 minutes**

MARK SCHEME

Maximum Mark: 50

Published

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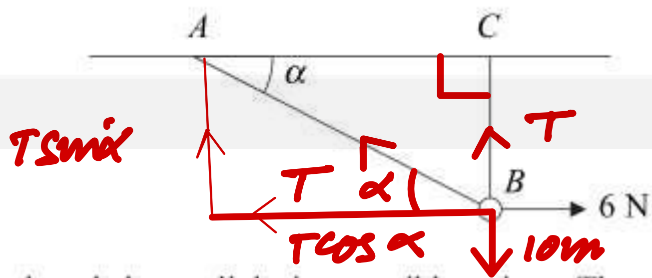
Q1:

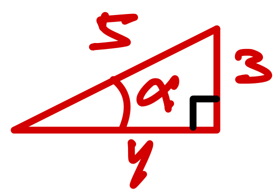
Figure 1



A smooth bead B is threaded on a light inextensible string. The ends of the string are attached to two fixed points A and C on the same horizontal level. The bead is held in equilibrium by a horizontal force of magnitude 6 N acting parallel to AC. The bead B is vertically below C and $\angle BAC = \alpha$, as shown in Figure 1. Given that $\tan\alpha = \frac{3}{4}$, find

(a) the tension in the string, **[2]**

(b) the weight of the bead. **[2]**



$\sin\alpha = 3/5$

(a) $6 = T\cos\alpha$

$6 = T\left(\frac{4}{5}\right)$

$T = \frac{30}{4} = 7.5N$ ANS

(b) $10m = T + T\sin\alpha$

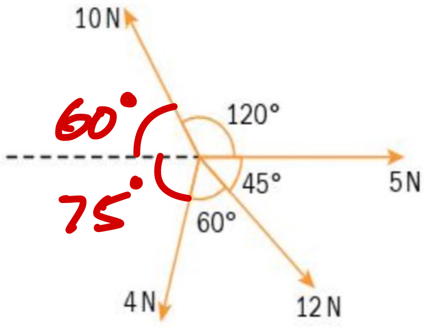
$10m = 7.5 + 7.5\left(\frac{3}{5}\right)$

$10m = 12$

$m = 1.2$ kg $\quad W = 12N$

ANS ANS

2.

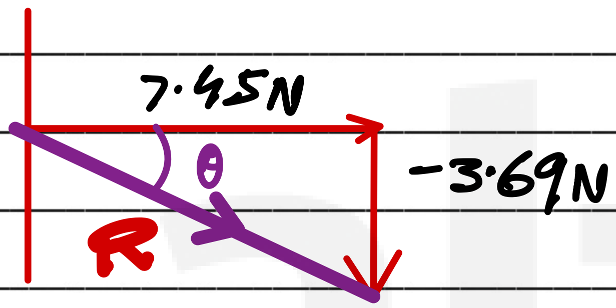


Four coplanar forces act at a point. The magnitude of the forces are 10 N, 5 N, 12 N and 4 N, and the directions in which the forces act are shown in the diagram. Calculate the magnitude and direction of the resultant of the four forces. [4]

R < $\Sigma F_x = ?$, $\Sigma F_y = ?$

$\Sigma F_x = 5 - 10\cos 60 + 12\cos 45^\circ - 4\cos 75^\circ = 7.45\,N$

$\Sigma F_y = 10\sin 60^\circ - 4\sin 75^\circ - 12\sin 45^\circ = -3.69\,N$



$R = 8.31\,N$

$\theta = 26.3^\circ$ below +ve X-axis

Ans

3. The resistance to the motion of a lorry of mass 5 tonnes is kv, where $v\,\mathrm{m\,s^{-1}}$ is the lorry's speed. With the engine working at 66 kW the lorry can attain a greatest steady speed of $12\,\mathrm{m\,s^{-1}}$ up a straight road that is inclined at $\sin^{-1}\frac{1}{20}$ to the horizontal.

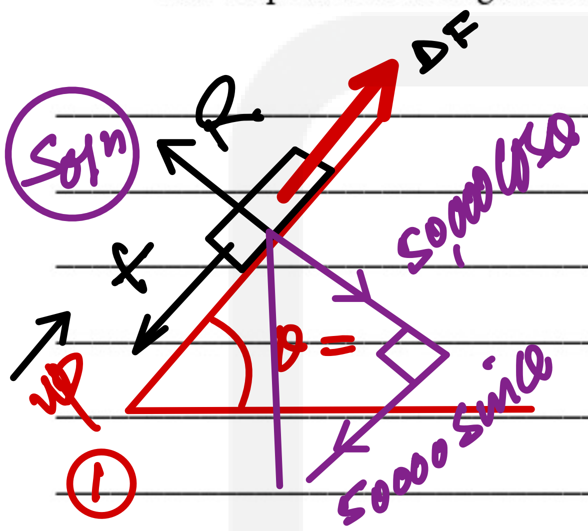
$m = 5000$ kg

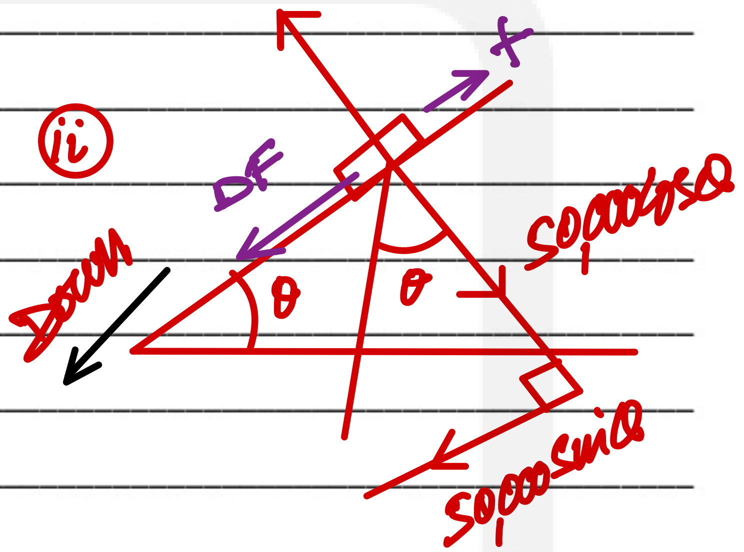
i) Show that $k = 250$. [3]

ii) Determine the greatest steady speed that the lorry can go down this slope with the engine still working at 66 kW. [4]

$\sin\theta = \frac{1}{20}$

Soln





(i)

$DF = f + 50{,}000\sin\theta$

$DF = KV + 50{,}000 \times \frac{1}{20}$

Power $= DF \times V$

$DF = \frac{66000}{12}$

$\frac{66000}{12} = K(12) + \frac{50{,}000}{20}$

$K = 250$

ANS

(ii)

$DF + 50000\sin\theta = f$

$\frac{66000}{V} + 50{,}000 \times \frac{1}{20} = KV$

$\frac{66000}{V} + 2500 = 250V$

$250V^2 - 2500V - 66000 = 0$

$V^2 - 10V - 264 = 0$

$V = 22$ m/sec

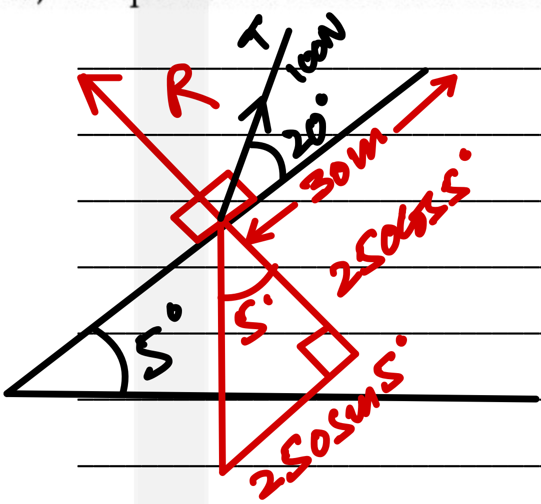
ANS

4. A block of mass 25 kg is dragged 30 m up a slope inclined at 5° to the horizontal by a rope inclined at 20° to the slope. The tension in the rope is 100 N and the resistance to the motion of the block is 70 N. The block is initially at rest. Calculate

✓i) the work done by the tension in the rope [2]

✓ii) the change in the potential energy of the block [2]

iii) the speed of the block after it has moved 30 m up the slope. [3]



$WD = 100\cos 20° \times 30$

$= 2819.07$

$= 2820 J$

ANS

③ Energy Equation

WD By Pulling force $= \Delta K + \Delta P + WD_f$

$2820 = \frac{1}{2} \times 25 \times V^2 + 654 + 70 \times 30$

$v = 2.29 m/sec$

ANS

② $\Delta P = mgh$

$= 25 \times 10 \times 30 \sin 5°$

$= 653.67 J$

$\Delta P = 654 J$

ANS

5.

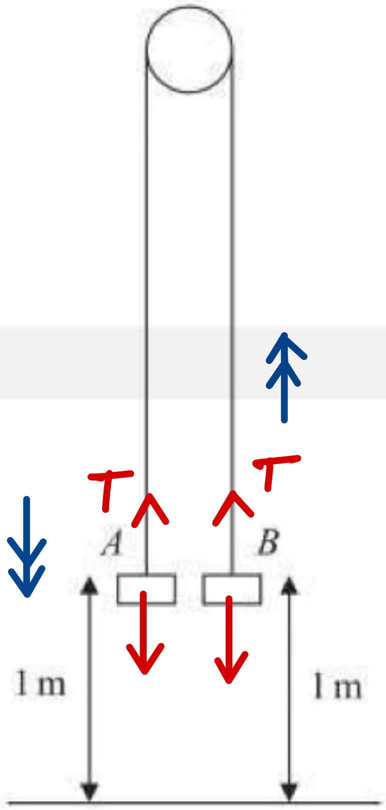


Figure 4

Two particles A and B have mass 0.4 kg and 0.3 kg respectively. The particles are attached to the ends of a light inextensible string. The string passes over a small smooth pulley which is fixed above a horizontal floor. Both particles are held, with the string taut, at a height of 1 m above the floor, as shown in Figure 4 The particles are released from rest and in the subsequent motion B does not reach the pulley.

✓(a) Find the tension in the string immediately after the particles are released. **[2]**

for A $4 - T = 0.4a$ $\quad a = \frac{10}{7}\text{ m/s}^2$ $\quad T = 3.43\text{N}$

for B $T - 3 = 0.3a$

✓(b) Find the acceleration of A immediately after the particles are released. **[2]**

$a = \frac{10}{7}\text{ m/s}^2$

When the particles have been moving for 0.5 s, the string breaks.

(c) Find the further time that elapses until B hits the floor. **[4]**

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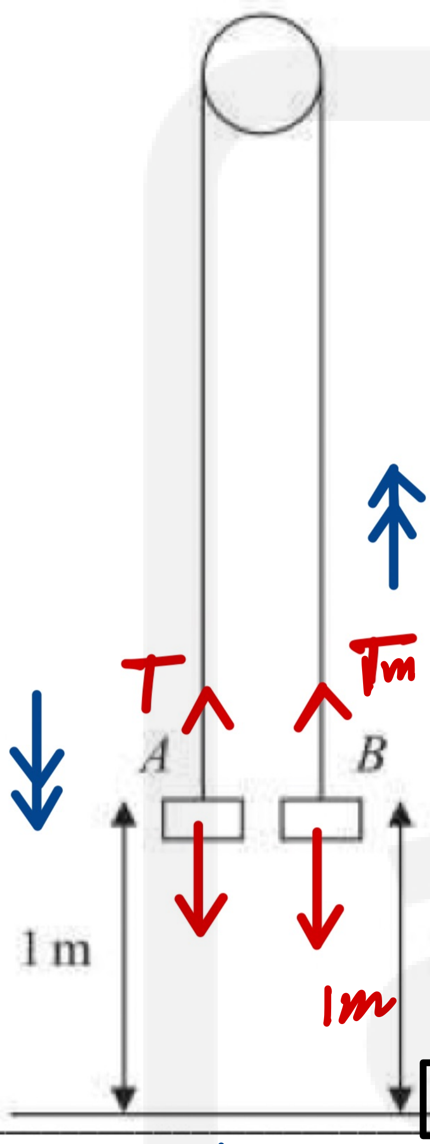
(ii) When the particles have been moving for 0.5 s, the string breaks.

(c) Find the further time that elapses until B hits the floor.



↑ for B $\quad v = u + at$

$v = 0 + \frac{10}{7}(0.5) = \frac{5}{7}\,m/sec$

↑ for B $\quad s = ut + \frac{1}{2}at^2$

$s = 0 + \frac{1}{2} \times \frac{10}{7}(0.5)^2$

$s = \frac{5}{28}\,m$

Opt #01 ↓ for B

$s = ut + \frac{1}{2}at^2$

$1 + \frac{5}{28} = -\frac{5}{7}t + \frac{1}{2}(10)(t)^2$

$1.179 = -0.714t + 5t^2$

$t = 0.562\ sec$ Ans

OR

Opt #2

for B ↑ Max Height

$v = 0$

$u = 0.714\ sec$

$a = -10\ m/s^2$

$v^2 = u^2 + 2as$

$s = 0.026\,m$

$v = u + at \quad t = 0.0714\ Sec$

for B ↓

$s = 1 + 0.179 + 0.125\,m = 1.024\,m$

$s = ut + \frac{1}{2}at^2$

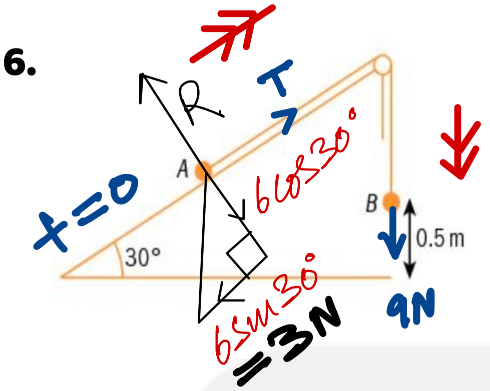
$1.026 = \frac{1}{2} \times 10 \times t^2$

$t = 0.453\ sec$

$t = 0.0714 + 0.453 = 0.524\ sec$ — Ans

↑ ↓

6.



Particles A of mass 0.6 kg and B of mass 0.9 kg are connected by a light inextensible string that passes over a smooth pulley that is fixed at the top of a smooth sloping flat surface that is inclined at an angle of 30° to the horizontal. Particle A lies on the slope and particle B is released from rest and falls 0.5 m to the floor, where it remains at rest. Particle A then continues to move up the slope.

✓ i) Show that the acceleration of the particles is $4\,\text{m}\,\text{s}^{-2}$ before B hits the floor and find the tension in the string. [3]

✓ ii) Calculate the speed of the particles just before particle B reaches the floor. [2]

iii) Assuming that it does not reach the pulley, calculate the further distance that particle A travels up the slope. [4]

① for B

$9 - T = 0.9a$ —— ①

for A $T - 3 = 0.6a$ —— ②

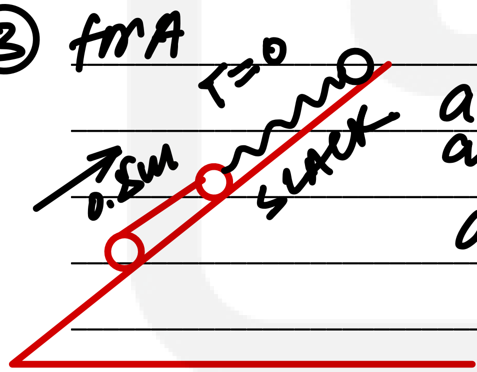
$a = 4\,m/s^2$ $T = 5.4N$ — ANS

② for B $v^2 = u^2 + 2as$

$v^2 = 2(4)(0.5)$

$v = 2\,m/sec$ — ANS

③ for A



$a = -g\sin\theta$

$a = -10 \times \sin 30°$

$a = -5\,m/s^2$

$v = 0$ (Max Height)

$u = 2\,m/sec$

$v^2 = u^2 + 2as$

$0 = 2^2 + 2(-5)s$

$s = 0.4m$

ANS

7. A car moves on a straight road. As the driver passes a point A on the road with a speed of $20\,\mathrm{ms}^{-1}$, he notices an accident ahead at a point B. He immediately applies the brakes and the car moves with an acceleration of $a\,\mathrm{ms}^{-2}$, where $a = \frac{3t}{2} - 6$ and t s is the time after passing A. When $t = 4$, the car passes the accident at B. The car then moves with a constant acceleration of $2\,\mathrm{ms}^{-2}$ until the original speed of $20\,\mathrm{ms}^{-1}$ is regained at a point C. Find

(i) the speed of the car at B, [4]

(ii) the distance AB, [3]

(iii) the time taken for the car to travel from B to C. [2]

Sketch the velocity-time graph for the journey from A to C. [2]

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① At $t=0$

speed $=20$ m/sec

At B $t=4$

$$a=\frac{3t}{2}-6$$

$$\int a\,dt = v$$

$$v=\frac{3}{2}\frac{t^2}{2}-6t+c$$

$$v=\frac{3}{4}t^2-6t+c$$

$t=0$ $v=20$ m/sec

$20=0-0+c$

$$c=20$$

$$v=\frac{3}{4}t^2-6t+20$$

$t=4$ at B

$$v=\frac{3}{4}\times 16-6(4)+20$$

$$=12-24+20$$

$$v=8\text{ m/sec}$$

— ANS

② Distance AB $=\int_0^4 \frac{3}{4}t^2-6t+20\,dt$

$$=\frac{3}{4}\frac{t^3}{3}-\frac{6t^2}{2}+20t$$

$$=\frac{t^3}{4}-3t^2+20t\Big|_0^4=48\text{ m}$$

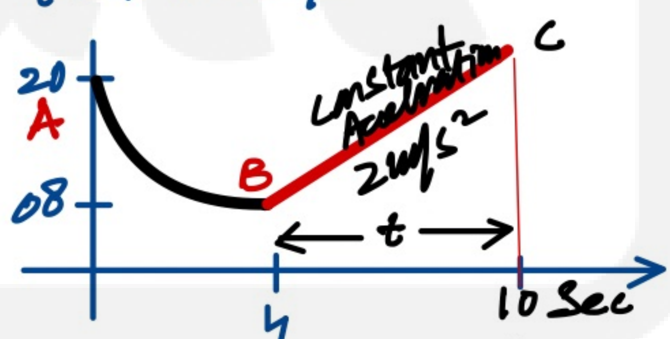
— ANS

③/④ $v=\frac{3}{4}t^2-6t+20$ $\quad 0\le t\le 4$ A to B

Quadratic Expression

$t=0$ $v=20$ m/sec

$t=4$ $v=8$ m/sec



gradient of v-t = Acceleration

$$a=\frac{12}{t}$$

$$2=\frac{12}{t}$$

$$t=6\text{ sec}$$

— ANS