University of Technology
Department of Laser&Optoelectronics Engineering
Final Examination 2011-2012

Subject: Engineering Mechanics
Division: Laser & optoelectronics ENG.
Examiner: Dr. Sudad Issam Younis

Class:1st year
Time:3 hours
Date: 4 / 6 /2012

Answer only five questions

Q1: The boat shown in figure (1) is to be pulled onto the shore using two ropes. Determine the magnitudes of the forces T and P acting in each rope to develop a resultant force of $400\ N$, directed along the keel aa for the following cases

a) If $\theta=45°$. *b)* If P is **minimum**.

(20 marks)

Q2: If the sack at A in figure (2) has a weight of **20 KN**, determine the weight of the sack at B and the force in each cord needed to hold the system in the equilibrium position shown.

(20 marks)

Q3: The uniform rod having a weight W and length l is supported at its ends against the surface at A & B shown in figure(3). If the rod is on the verge of slipping when $\theta=30°$, determine the coefficient of static friction μ_s at A & B. Neglect the thickness of the rod for the calculation.

(20 marks)

Q4: **a**-Find the centroid for the shaded area shown in figure (4).
b-Find the moment of inertia about X-axis.

(20 marks)

Q5: A car moves from rest in a straight line such that for a short time its velocity is defined by $v=(0.9t^2+0.6t)$ ***m/sec***, where t in seconds. Determine its position and acceleration after **3 seconds**.

(20 marks)

Q6: The snowmobile shown in figure (5) is traveling at 10 m/sec when it leaves the embankment at A. Determine the time of flight from A to B and the range R of the trajectory.

(20 marks)

(Good luck)

(Turn over)

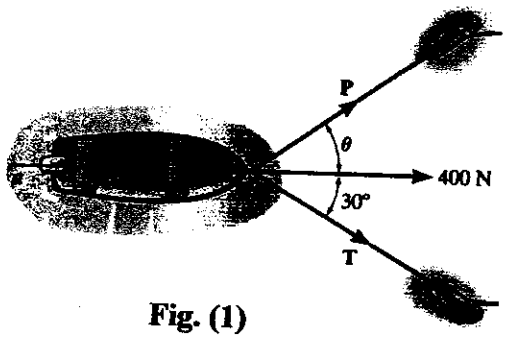


Fig. (1)

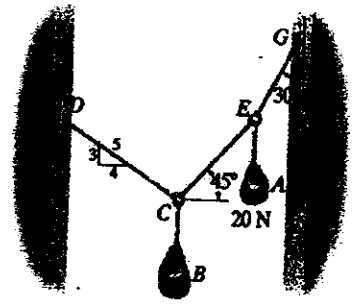


Fig. (2)

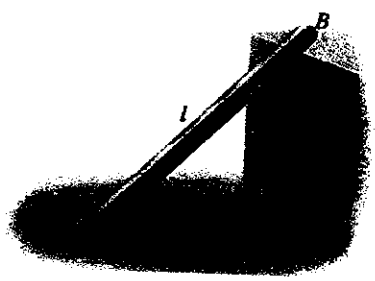
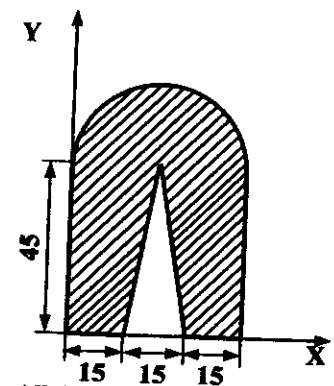


Fig. (3)



All dimensions in mm

Fig. (4)

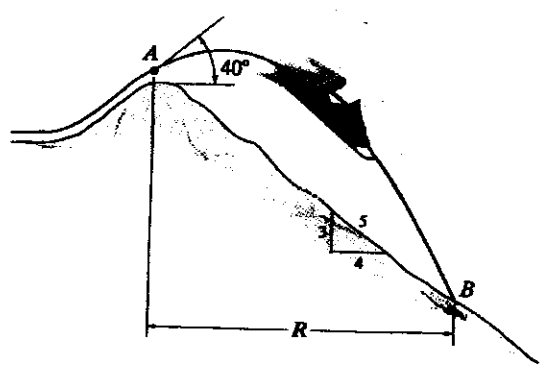


Fig. (5)

حلول اسئلة النموذج رقم (1)

الاول ميكانيكا هندسي / الفيزيا وبصريات

(الامتحان النهائي 2011 / 2015)

Q1/ (a) If $\theta = 45^\circ$

$\Sigma F_y = 0$ [The Resultant is horizontally.]

$P\sin\theta - T\sin 30 = 0$

$P\sin 45 - T\sin 30 = 0$ —(1)

$R_x = P\cos\theta + T\cos 30$ —(*)

$400 = P\cos 45 + T\cos 30$ —(2)

from 1 $P = \frac{T\sin 30}{\sin 45}$ sub in (2)

$400 = T\frac{\sin 30}{\tan 45} + T\cos 30 = 1.366\,T$

$\boxed{T = 292.82\ N} \Rightarrow \boxed{P = 207.06\ N}$

(b) If P is minimum $\Rightarrow$ The angle between the ropes is 90

$\therefore \theta = 60^\circ$ & $P\sin 60 - T\sin 30 = 0$

sub in (*)

$400 = P\cos 60 + T\cos 30$

$400 = T\frac{\sin 30}{\tan 60} + T\cos 30 = 1.154\,T$

$T = 346.4\ N \Rightarrow P = 200\ N$

OR by $R = \sqrt{T^2 + P^2}$

$400 = \sqrt{T^2 + \left(\frac{T\sin 30}{\sin 60}\right)^2}$

$= T\sqrt{1 + \frac{\sin^2 30}{\sin^2 60}} = 1.154\,T$

$\boxed{T = 346.4\ N}$

$\boxed{P = 200\ N}$

Q2 Free body diagram

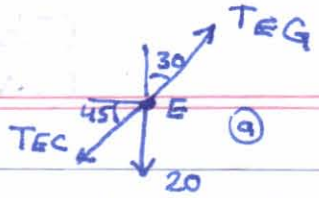
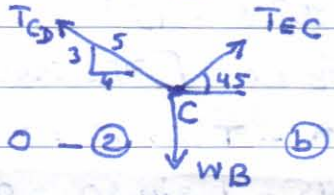


figure (a)

$\xrightarrow{+} \Sigma F_x = 0$

$T_{EG}\sin30 - T_{EC}\cos45 = 0$ — (1)

$+\uparrow \Sigma F_y = 0 \quad T_{EG}\cos30 - T_{EC}\sin45 - 20 = 0$ — (2)



from (1)

$T_{EG} = T_{EC}\dfrac{\cos45}{\sin30}$ (1.414 T_{EC}) sub in (2)

$T_{EC}\dfrac{\cos45}{\tan30} - T_{EC}\sin45 - 20 = 0$

$T_{EC}(1.2247 - 0.707) - 20 = 0$

$T_{EC} = \dfrac{20}{0.517} = 38.637$ KN

$\therefore T_{EG} = 54.641$ KN

figure (b)

$\xrightarrow{+} \Sigma F_x = 0 \quad T_{EC}\cos45 - T_{CD} * \frac{4}{5} = 0$

$38.637\cos45 - T_{CD} * 0.8 = 0$

$T_{CD} = 34.15$ KN

$\uparrow \Sigma F_y = 0$

$T_{EC}\sin45 + T_{CD} * \frac{3}{5} - W_B = 0$

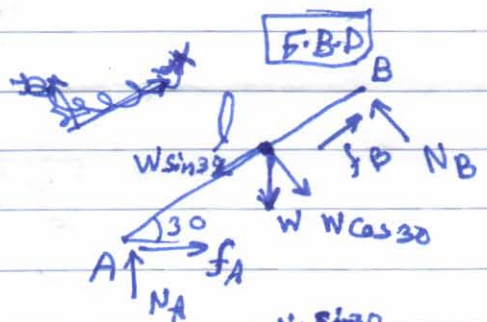
$38.637\sin45 + 34.15 * \frac{3}{5} = W_B$

$W_B = 47.81$ KN

Q3 $f_A = \mu_s N_A$

$f_B = \mu_s N_B$

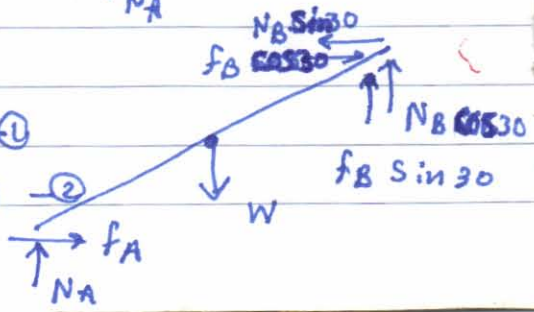
F.B.D



$\xrightarrow{+} \Sigma F_x = 0$

$\mu_s N_A + \mu_s N_B\cos30 - N_B\sin30 = 0$ — (1)

$+\uparrow \Sigma F_y = 0 \quad N_A - W + \mu_s N_B\sin30 + N_B\cos30 = 0$ — (2)



$\circlearrowleft + \Sigma M_A = 0$

$N_B(\ell) - W\left(\frac{\ell}{2}\right)\cos 30 = 0 \quad \div \ell$

$N_B = 0.433\,W \quad \text{——} \; (3)$ sub in (1) & (2) yields

$\mu_s N_A = N_B(\sin 30 + \mu_s \cos 30) = 0.433\,W\,(0.5 + \frac{\sqrt{3}}{2}\mu_s) \quad (4)$

$N_A = W - N_B(\mu_s \sin 30 + \cos 30) = W - 0.433\,W(0.5\mu_s + \frac{\sqrt{3}}{2}) \quad (5)$

sub N_A from (5) in (4) Yields

$\div W$

$\mu_s\left[W - 0.433\,W(0.5\mu_s) - 0.433\,W\frac{\sqrt{3}}{2}\right] = 0.433\,W(0.5 + \frac{\sqrt{3}}{2}\mu_s)$

$\mu_s[1 - 0.2165\,\mu_s - 0.3749] = 0.2165 + 0.3749\,\mu_s$

$\mu_s - 0.2165\,\mu_s^2 - 0.3749\,\mu_s - 0.2165 + 0.3749\,\mu_s = 0$

$0.2165\,\mu_s^2 - \mu_s + 0.2165 = 0$

$\mu_s^2 - 4.6189\,\mu_s + 1 = 0$

$\boxed{\mu_s = 0.228}$

Q5 $v = 0.9t^2 + 0.6t$

$v = \frac{dx}{dt} \Rightarrow dx = v\,dt$

$\int_0^x dx = \int_0^3 (0.9t^2 + 0.6t)\,dt$

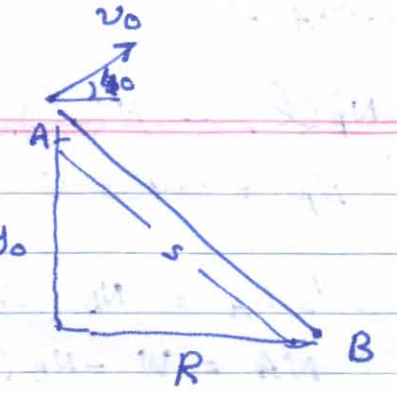
$x = \left[0.3t^3 + 0.3t^2\right]_0^3 = 0.3(27) + 0.3(9)$

$x = 10.8\ m.$

$\because v = f(t), \; a = \frac{dv}{dt} = 1.8t + 0.6$

$a_{3s} = 1.8(3) + 0.6 = 6\ m/sec^2$

Q6



$y_0 = s * \frac{3}{5}$

$R = s * \frac{4}{5}$

$v_{ox} = v_0 \cos 40$

$v_{oy} = v_0 \sin 40$

$x = v_{ox} t$

$R = v_0 \cos 40\, t$

$s(\frac{4}{5}) = 10 \cos 40\, t$ ——— (1)

$y = y_0 + v_0 \sin\theta\, t - \frac{1}{2} g t^2$

$0 = s(\frac{3}{5}) + 10 \sin 40\, t - 5t^2$ ——— (2)

$5t^2 - 6.428t - 3 = 0$

$t = \frac{6.428 \pm \sqrt{(6.428)^2 + 60}}{10}$

$t = 1.649$ sec

-ve (ignored)

Sub for (s) from (1)

$\boxed{s = 9.575\, t}$

$9.575\, t(\frac{3}{5}) + 10 \sin 40\, t - 5t^2 = 0 \quad * -\frac{1}{5}$

$t^2 - 2.4346\, t = 0 \qquad t(t - 2.4346) = 0$

$t = 0$, $\boxed{2.435 \text{ sec}}$

$\therefore R = 9.575\,(2.435)(\frac{4}{5}) = \boxed{18.65 \text{ m.}}$