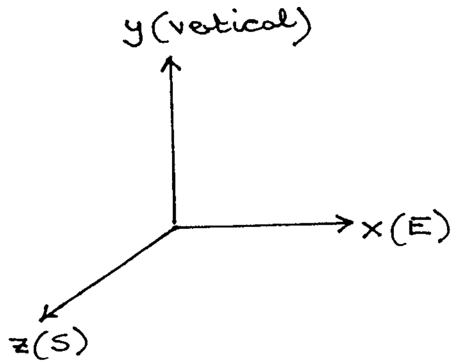
M2.



(i) Take co-ordinates with x=East, y=vertical, and z=South.

Initial position of plane is $\underline{r}_p(0) = (0,8,0)$ km

Velocity of plane is $\underline{v}_p = (800\sin30^0, 0, -800\cos30^0) = (400,0,-693)$ km/h

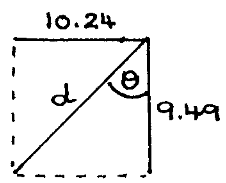
Position of plane at t=60 s is $\underline{r}_p(t) = \underline{r}_p(0)+\underline{v}_p/60 = (6.67,8,-11.55)$ km

Horizontal distance to beacon at t=0 is $[9^2-8^2]^{1/2} = 4.12$ km

Position of beacon is $\underline{r}_B = \underline{r}_p(0) + (-4.12\sin60^0,-8,-4.12\cos60^0) = (-3.57,0,-2.06)$ km

Position of beacon relative to the plane at t=60 s is $\underline{r}_B-\underline{r}_p(t) = (-10.24,-8,9.49)$ km

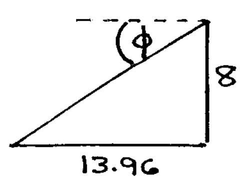
(ii) In the horizontal plane the displacement is as shown here:



Angle θ is given by $\tan\theta = 10.24/9.49$, $\theta = 47.2^0$

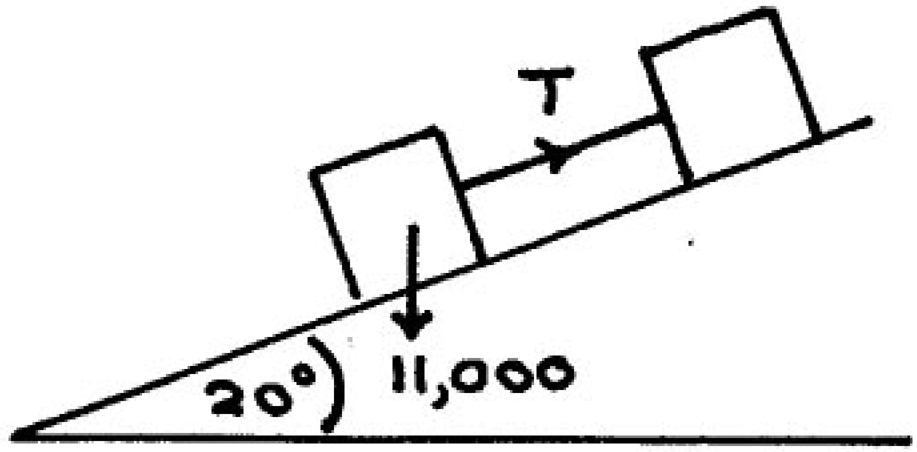
Hence bearing is $S47.2^0W$

Horizontal separation is $d = [(10.24)^2+(9.49)^2]^{1/2} = 13.96$ km



Depression is given by $\tan\varphi = 8/13.96$, $\varphi = 29.8^0$.

M24.



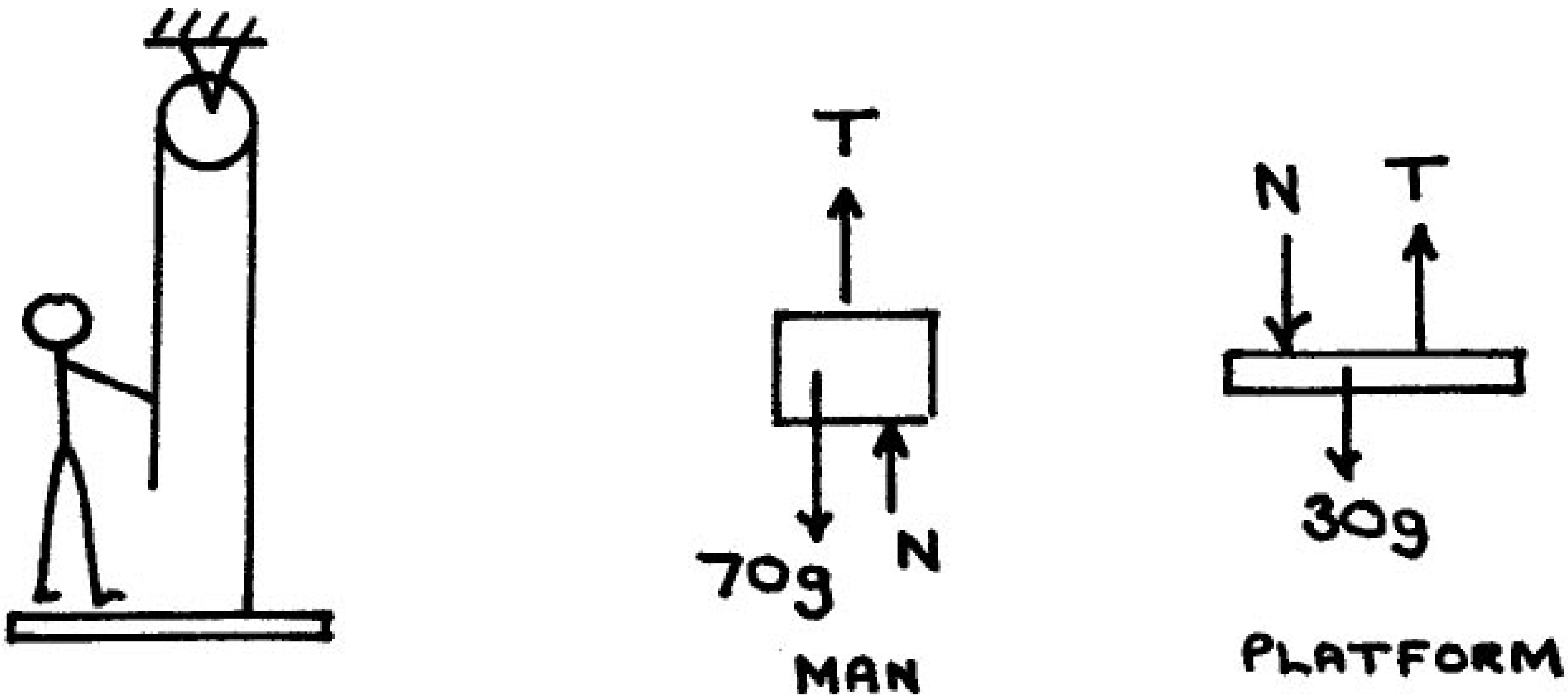
The maximum tension in the rope is 4500 N. The mass of the student's car is 11000/g = 1121 kg, and the component of its weight down the incline is $11000\sin(20^0)$.

Hence $4500 - 11000\sin(20^0) = 1121a$

Maximum possible acceleration $a = 0.658$ m/s^2

Distance travelled in t = 10s is given by $d = at^2/2 = 50a = 32.9$ m

M26.



There is a normal force N exerted upward on the man by the platform, and therefore there must be an equal and opposite force exerted downward on the platform by the man. Under the action of the weights, tension, and normal forces both the man and the platform have an upward acceleration of 0.9 m/s^2.

Hence $T + N - 70g = 70(0.9)$ ....(i)

$T - N - 30g = 30(0.9)$ ....(ii)

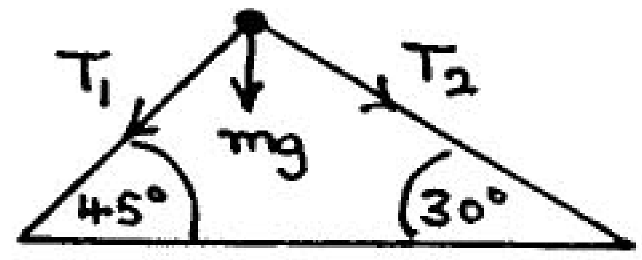
Adding (i) and (ii) $2T = 100(0.9) + 100g = 1071$

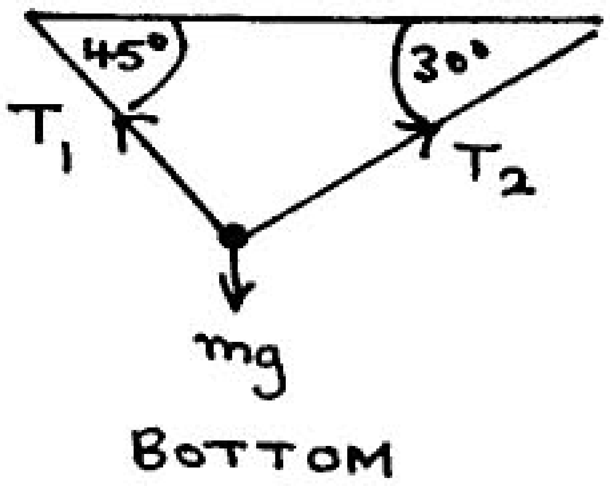
$T = 536$ Newtons

From (i) $N = 70(g+0.9) - T = 750 - T$

$= 214$ Newtons

M44.





The bead has a centripetal acceleration of $r\omega^2$ directed towards the centre of its circular path.

When at the top $\quad T_1\sin(45^0) + T_2\sin(30^0) + mg = mr\omega^2$ ....(i)

When at the bottom $\quad T_1\sin(45^0) + T_2\sin(30^0) - mg = mr\omega^2$ ....(ii)

At the bottom the tensions must provide the centripetal force plus the weight, while at the top they provide the centripetal force minus the weight. Hence the tensions are maximum, and will cause the cord to break, when the mass is at the bottom.

Horizontal forces: $\quad T_1\cos(45^0) - T_2\cos(30^0) = 0$

$T_1 = 1.225\ T_2$ ....(iii)

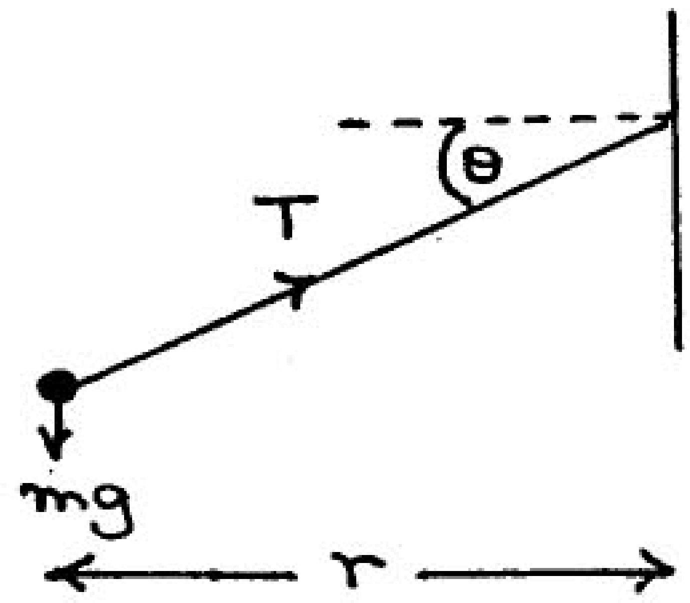
Cord 1 is the one which will break.

From (ii) and (iii) $\quad T_1(\sin45^0 + 0.816\sin30^0) = m(r\omega^2 + g)$

$1.115T_1 = 28.96$

$T_1 = 26\ N$

M45.



$r = 1.5\cos\theta$

$v = 5$ m/s

The mass has a centripetal acceleration of mv^2/r directed towards the post.

Vertical forces: $\quad T\sin\theta - mg = 0$

$\therefore T\sin\theta = 49$ ....(i)

Horizontal forces: $\quad T\cos\theta = mv^2/r = mv^2/(1.5\cos\theta)$

$\therefore T\cos^2\theta = mv^2/1.5 = 83.3$ ....(ii)

From (i) and (ii) $\quad \cos^2\theta/\sin\theta = 1.7$

$\cos^2\theta + \sin^2\theta = 1$

$\therefore \sin^2\theta + 1.7\sin\theta - 1 = 0$

$\sin\theta = 0.462,\ \theta = 27.5^0$

Then from (i) $\quad T = mg/\sin\theta = 5(9.81)/0.462 = 106\ N$

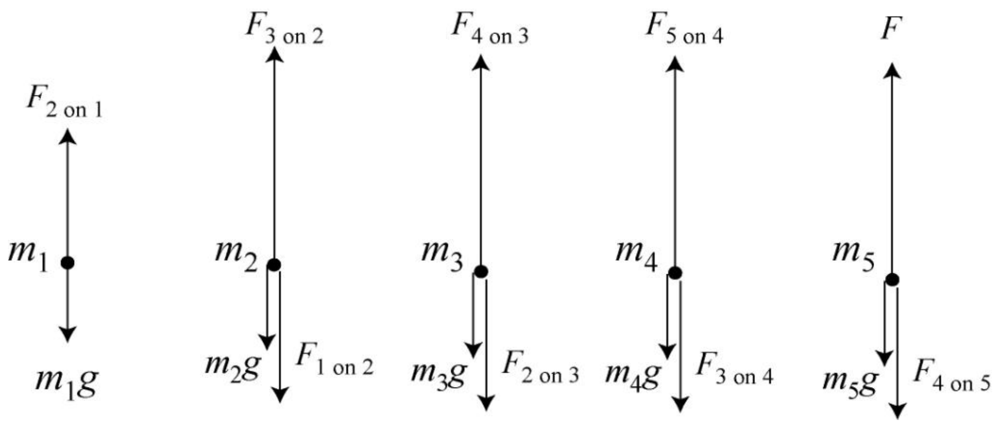
4-65. Since the period of a uniform circular motion is $T = 2\pi r / v$, where r is the radius and v is the speed, the centripetal acceleration can be written as

$$a = \frac{v^2}{r} = \frac{1}{r}\left(\frac{2\pi r}{T}\right)^2 = \frac{4\pi^2 r}{T^2}.$$

Based on this expression, we compare the (magnitudes) of the wallet and purse accelerations, and find their ratio is the ratio of r values. Therefore, $a_{\text{wallet}} = 1.50\, a_{\text{purse}}$. Thus, the wallet acceleration vector is

$$a = 1.50[(2.00 \text{ m/s}^2)\hat{\text{i}} + (4.00 \text{ m/s}^2)\hat{\text{j}}] = (3.00 \text{ m/s}^2)\hat{\text{i}} + (6.00 \text{ m/s}^2)\hat{\text{j}}.$$

5-43. The links are numbered from bottom to top. The forces on the first link are the force of gravity $m\vec{g}$, downward, and the force $\vec{F}_{2\text{on}1}$ of link 2, upward, as shown in the free-body diagram below (not drawn to scale). Take the positive direction to be upward. Then Newton's second law for the first link is $F_{2\text{on}1} - m_1 g = m_1 a$. The equations for the other links can be written in a similar manner (see below).



(a) Given that $a = 2.50\text{ m/s}^2$, from $F_{2\text{on}1} - m_1 g = m_1 a$, the force exerted by link 2 on link 1 is

$$F_{2\text{on}1} = m_1(a+g) = (0.100\text{ kg})(2.5\text{ m/s}^2 + 9.80\text{ m/s}^2) = 1.23\text{ N}.$$

(b) From the free-body diagram above, we see that the forces on the second link are the force of gravity $m_2\vec{g}$, downward, the force $\vec{F}_{1\text{on}2}$ of link 1, downward, and the force $\vec{F}_{3\text{on}2}$ of link 3, upward. According to Newton's third law $\vec{F}_{1\text{on}2}$ has the same magnitude as $\vec{F}_{2\text{on}1}$. Newton's second law for the second link is

$$F_{3\text{on}2} - F_{1\text{on}2} - m_2 g = m_2 a$$

so

$$F_{3\text{on}2} = m_2(a + g) + F_{1\text{on}2} = (0.100\text{ kg})\,(2.50\text{ m/s}^2 + 9.80\text{ m/s}^2) + 1.23\text{ N} = 2.46\text{ N}.$$

(c) Newton's second for link 3 is $F_{4on3} - F_{2on3} - m_3 g = m_3 a$, so

$$F_{4on3} = m_3(a + g) + F_{2on3} = (0.100 \text{ N}) (2.50 \text{ m/s}^2 + 9.80 \text{ m/s}^2) + 2.46 \text{ N} = 3.69 \text{ N},$$

where Newton's third law implies $F_{2on3} = F_{3on2}$ (since these are magnitudes of the force vectors).

(d) Newton's second law for link 4 is

$$F_{5on4} - F_{3on4} - m_4 g = m_4 a,$$

so

$$F_{5on4} = m_4(a + g) + F_{3on4} = (0.100 \text{ kg}) (2.50 \text{ m/s}^2 + 9.80 \text{ m/s}^2) + 3.69 \text{ N} = 4.92 \text{ N},$$

where Newton's third law implies $F_{3on4} = F_{4on3}$.

(e) Newton's second law for the top link is $F - F_{4on5} - m_5 g = m_5 a$, so

$$F = m_5(a + g) + F_{4on5} = (0.100 \text{ kg}) (2.50 \text{ m/s}^2 + 9.80 \text{ m/s}^2) + 4.92 \text{ N} = 6.15 \text{ N},$$

where $F_{4on5} = F_{5on4}$ by Newton's third law.

(f) Each link has the same mass ($m_1 = m_2 = m_3 = m_4 = m_5 = m$) and the same acceleration, so the same net force acts on each of them:

$$F_{net} = ma = (0.100 \text{ kg}) (2.50 \text{ m/s}^2) = 0.250 \text{ N}.$$