STAEDTLER® No. 937 811E Engineer's Computation Pad

••24 A cave rescue team lifts an injured spelunker directly upward and out of a sinkhole by means of a motor-driven cable. The lift is performed in three stages, each requiring a vertical distance of 10.0 m: (a) the initially stationary spelunker is accelerated to a speed of 5.00 m/s; (b) he is then lifted at the constant speed of 5.00 m/s; (c) finally he is decelerated to zero speed. How much work is done on the 80.0 kg rescuee by the force lifting him during each stage?

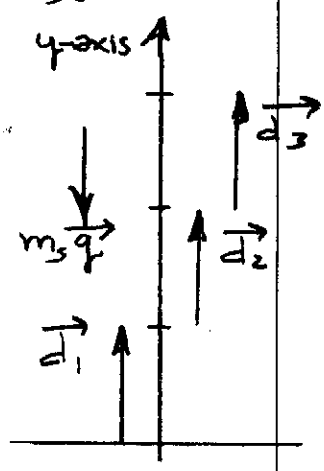
NET WORK DONE ON SPELUNKER

$$= W_{Spel}^{net} = \int_i^f \vec{F}_{on\,spel}^{net} \cdot d\vec{r}$$

$$W_s^{net} = \int_i^f \left(\vec{F}_{s,grav} + \vec{F}_{s,machine}\right) \cdot d\vec{r}$$

$$= \int_i^f \vec{F}_g \cdot d\vec{r} + \int_i^f \vec{F}_{s,m} \cdot d\vec{r}$$

$$= m\vec{g} \cdot \int_i^f d\vec{r} + W_{by\,machine}^{on\,s}$$



$$W_{on\,spel}^{net} = m\vec{g} \cdot \vec{d} + W_{by\,machine}^{on\,spel}$$

WORK-ENERGY THEOREM

$$W_{on\,spel}^{net} = \Delta K = \frac{1}{2} m_s v_f^2 - \frac{1}{2} m_s v_i^2$$

$$\Rightarrow -mg(y_f - y_i) + W_{by\,m}^{on\,s} = \frac{1}{2} m_s (v_f^2 - v_i^2)$$

$$W_{by\,m}^{on\,s} = mg(y_f - y_i) + \frac{1}{2} m_s (v_f^2 - v_i^2)$$

a) $= 80.0(9.80)(10.0 - 0.00) + \frac{1}{2} 80.0 (5.00^2 - 0^2)$

$= 7{,}840 + 1{,}000 = 8{,}840$ (Joules = Nm)

Machine does work against gravity + gives it KE

b) $W_{by\,m}^{on\,s} = 80.0(9.80)(20.0 - 10.0) + \frac{1}{2}(80.0)(5.00^2 - 5.00^2)$

$= 7{,}840 + 0 = 7{,}840$ (Joules = Nm)

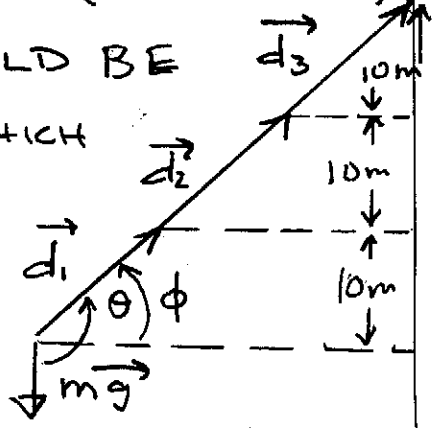
Machine only does work against gravity

c) $W_{by\,m}^{on\,s} = 80.0(9.80)(30.0 - 20.0) + \frac{1}{2}(80.0)(0.00^2 - 5.00^2)$

$= 7{,}840 - 1{,}900 = 6{,}840$ (Joules = Nm)

Machine works against gravity and takes KE

NOTE THE PROBLEM RESULT WOULD BE THE SAME FOR AN ANGLED SHAFT WHICH YIELDS THE SAME VERTICLE DISPLACEMENT SINCE



$$W_{by\,gravity}^{on\,s} = m\vec{g} \cdot \vec{d} = mgd(\cos\theta = -\sin\phi) = -mg(10m)$$