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Dynamics

9. a. $a = \frac{dv}{dt}$

$$\int_0^t a\,dt = v - u$$

$\therefore\ v = u + at$

b. $v^2 = u^2 + 2uat + a^2t^2$

$= u^2 + 2a(ut + \frac{1}{2}at^2)$

$= u^2 + 2as$

c. $v = \frac{ds}{dt}$

$\frac{ds}{dt} = u + at$

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

d. $s = \frac{1}{2}gt^2 = 80\,m$

$v = gt = 40\,ms^{-1}$

If it took 50 seconds, air resistance would not be negligible so suvat can't be used.

e. a. $v = u + \bar{a}t$ where $\bar{a}$ is time averaged acceleration

b. c. can't be easily fixed but do hold for short t where a can be considered constant

10. $P = Fv \Rightarrow \frac{dv}{dt} \cdot v = \frac{P}{m}$

$$\Rightarrow \frac{1}{2}v^2 = \frac{P}{m}t$$

$$\Rightarrow v = \sqrt{\frac{2P}{m}t}$$

$$a = \frac{P}{mv} = \frac{P}{\sqrt{2Pt_m}} = \sqrt{\frac{P}{2t_m}}$$

a. $v(7) = 18.7\,ms^{-1}$
$\approx 19\,ms^{-1}$ (2sf)

b. $a(7) = 1.3\,ms^{-2}$ (2sf)

This is fairly reasonable. A gearbox means as ω (angular speed of wheel) increases, τ decreases so $P = \tau\omega$ is roughly constant.

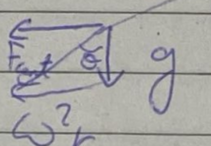
11. a. $v = \omega r$

b. $T = \frac{2\pi}{\omega}$

c. $a = \omega^2 r$

d. $E_k = \frac{1}{2}mr^2\omega^2$

e.



$$\theta = \arctan\left(\frac{\omega^2 r}{g}\right)$$

$$T = m\sqrt{g^2 + (\omega^2 r)^2}$$

12. a. $E_{k,1} = \frac{1}{2}mr^2\omega^2$ fixed axis

$E_{k,2} = \frac{1}{2}mr^2\omega^2 + \frac{1}{2}m(r\omega)^2 = mr^2\omega^2$ rolling w/o slipping

rotational translational

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6. i. $dm = \frac{2\pi r\,dr}{\pi R^2} m = \frac{2mr}{R^2} dr$

ii. $v = \omega r$

iii. $dE_k = \frac{mr}{R^2} dr \cdot \omega^2 r^2 = \frac{m\omega^2 r^3 dr}{R^2}$

iv. $\exists E_k = \int_0^R dE_k = \frac{1}{4} \frac{m\omega^2 R^4}{R^2}$

$= \frac{1}{4} m R^2 \omega^2$