Exercise 1. Estimate & Compare the average recoil forces for each of the following guns: Assume 26 inch barrel length. 4.45 Newtons=1 lb

Gun/Round	Projectile mass	Muzzle Speed (fps)	IMPULSE = Momentum Change (kg m/s)	Time in Barrel (~~s~~)	Average Force (Newtons)	Average Force (lb)
410 gauge	14 g (½ oz)	1200 366 m/s	5.12	3.61 ms	1420	320
20 gauge	35 g (1 ¼ oz)	1550 473 m/s	16.6	2.80	5930	1330
12 gauge	42 g (1 ½ oz)	1500 457 m/s	19.2	2.89	6645	1490
12 slug	28 g (1 oz)	1680 512 m/s	14.3	2.58	5560	1250
10 gauge	38.5 g (1 3/8 oz)	1450 442 m/s	17.0	3.00	5698	1280
22 rimfire	2.6 g (40 gr)	1080 (330 m/s)	0.86	4.0	214	48
223 Rem	3.565 g (55 gr)	3240 (988 m/s)	3.52	1.34	2640	592
.30-06	11.67 g (180 gr)	2700 (823 m/s)	9.60	1.60	5990	1345
577 Tyrannosaur	48.62 g (750 gr)	2518 768 m/s	37.3	1.72	21730	4880

The IMPULSE is the momentum change $\Delta p = m\Delta v = m(v_f - 0) = mv_f$

Estimate Time in barrell

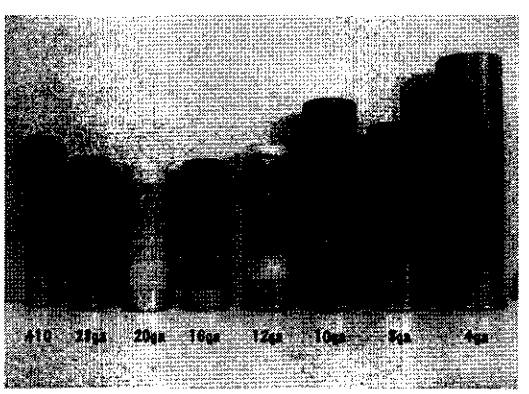
$$x(t) = \cancel{x_0}^{0} + \cancel{v_0}^{0} t + \tfrac{1}{2}at^2 \qquad v(t) = \cancel{v_0}^{0} + at$$

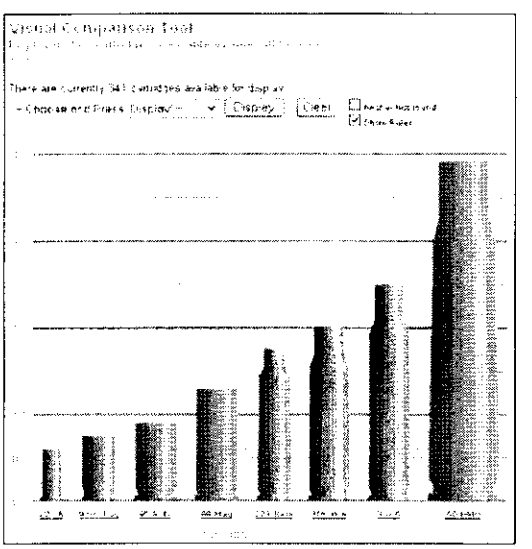
$$x = \tfrac{1}{2}at^2 \qquad v = at$$

$$x = \tfrac{1}{2}\left(\tfrac{v}{t}\right)t^2$$

$$x = \tfrac{1}{2}vt$$

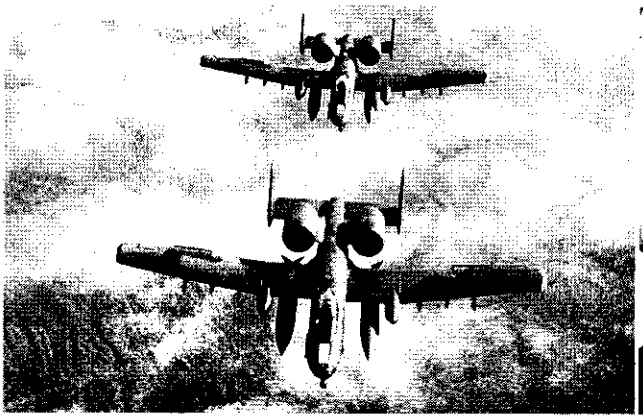
$$t = \frac{2x}{v} = \frac{2(0.66)}{v} = \frac{1.32}{v}$$





http://www.armoryblog.com/firearms/ammo/shotgun-shell-comparison/

http://ammoguide.com/cgi-bin/aicompare.cgi?sn=LMwHEKStVD



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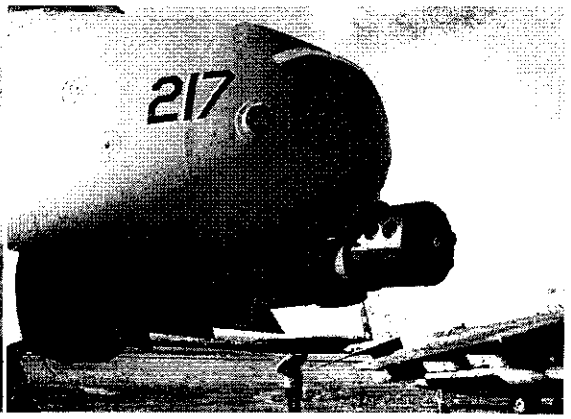

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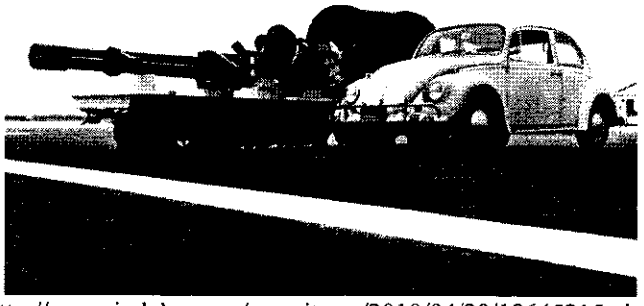


http://www.indybay.org/newsitems/2010/04/20/18645215.php

Exercise 2. The A-10 Thunderbolt/Warthog was specifically designed for close air support. It is powered by two General Electric turbofan engines which produce a thrust of 9065 lb each. The A-10 contains the Avenger 30mm cannon which has a max rate of fire of 70 rounds per second, each of which has a 0.68 kg depleted Uranium projectile with a muzzle speed of 1000 m/s. The claim is often made that the average force of recoil from the cannon exceeds the forward thrust of one of the engines. Prove this is true – calculate the average force associated with the recoil.
(4.45 N = 1 lb).

Momentum change of aircraft = momentum change of projectile

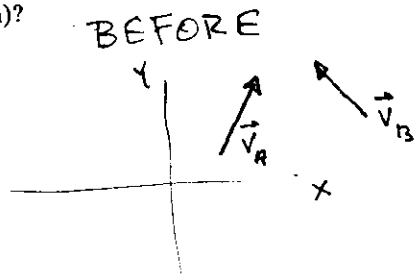
$$\text{Average Force} = \frac{\Delta p}{\Delta t} = \frac{m_{proj}\Delta v_{projectile}}{\Delta t} = \frac{(0.68\,kg)(1000\,m/s)}{(1/70\,s)}$$

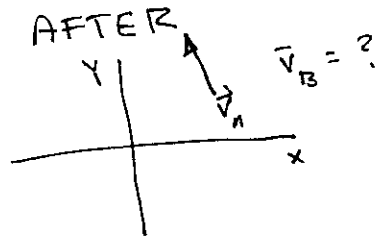
$$= 4.76\times10^{4} \text{ Newtons}$$

$$= 10\,700 \text{ lb.}$$

which is greater than thrust of one engine.

••74 Two 2.0 kg bodies, A and B, collide. The velocities before the collision are $\vec{v}_A = (15\hat{i} + 30\hat{j})$ m/s and $\vec{v}_B = (-10\hat{i} + 5.0\hat{j})$ m/s. After the collision, $\vec{v}'_A = (-5.0\hat{i} + 20\hat{j})$ m/s. What are (a) the final velocity of B and (b) the change in the total kinetic energy (including sign)?





$$\text{Total Init } \vec{P} = \text{Total Final } \vec{P}$$

$$\vec{P}_{A_i} + \vec{P}_{B_i} = \vec{P}_{A_f} + \vec{P}_{B_f}$$

$$\cancel{m}\vec{V}_{A_i} + \cancel{m}\vec{V}_{B_i} = \cancel{m}\vec{V}_{A_f} + \cancel{m}\vec{V}_{B_f}$$

$$(15\hat{i} + 30\hat{j}) + (-10\hat{i} + 5\hat{j}) = (-5\hat{i} + 20\hat{j}) + \vec{V}_{B_f}$$

$$\vec{V}_{B_f} = 10\hat{i} + 15\hat{j} \quad \text{m/s}$$

$$\text{Initial KE} = \tfrac{1}{2}mV_{A_i}^2 + \tfrac{1}{2}mV_{B_i}^2$$

$$V_{A_i} = \sqrt{15^2 + 30^2} = 33.54 \text{ m/s}$$

$$V_{B_i} = \sqrt{(-10)^2 + 5^2} = 11.18 \text{ m/s}$$

$$= \tfrac{1}{2}\,2\,(33.54)^2 + \tfrac{1}{2}\,2\,(11.18)^2$$

$$= 1250 \text{ Joules}$$

$$\text{Final KE} = \tfrac{1}{2}mV_{A_f}^2 + \tfrac{1}{2}mV_{B_f}^2$$

$$V_{A_f} = \sqrt{(-5)^2 + 20^2} = 20.62 \text{ m/s}$$

$$V_{B_f} = \sqrt{10^2 + 15^2} = 18.03 \text{ m/s}$$

$$= \tfrac{1}{2}\,2\,(20.62)^2 + \tfrac{1}{2}\,2\,(18.03)^2$$

$$= 733 \text{ Joules}$$

$$\text{Change in KE} = \text{Final KE} - \text{Init KE} = -516 \text{ Joules}$$

sec. 9-11 Collisions in Two Dimensions

••71 In Fig. 9-21, projectile particle 1 is an alpha particle and target particle 2 is an oxygen nucleus. The alpha particle is scattered at angle $\theta_1 = 64.0°$ and the oxygen nucleus recoils with speed 1.20×10^5 m/s and at angle $\theta_2 = 51.0°$. In atomic mass units, the mass of the alpha particle is 4.00 u and the mass of the oxygen nucleus is 16.0 u. What are the (a) final and (b) initial speeds of the alpha particle?

A glancing collision that conserves both momentum and kinetic energy.

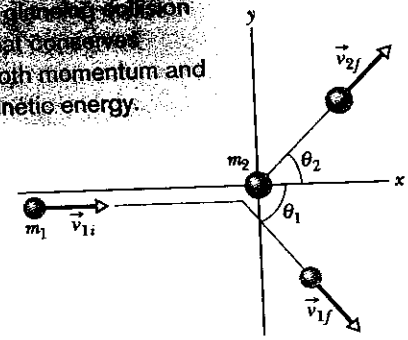


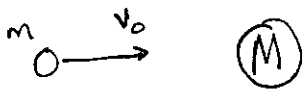
Fig. 9-21 An elastic collision between two bodies in which the collision is not head-on. The body with mass m_2 (the target) is initially at rest.

$m = 4$

$M = 16$

Note that the mass units will cancel in the equations so we don't have to convert to kg.

BEFORE



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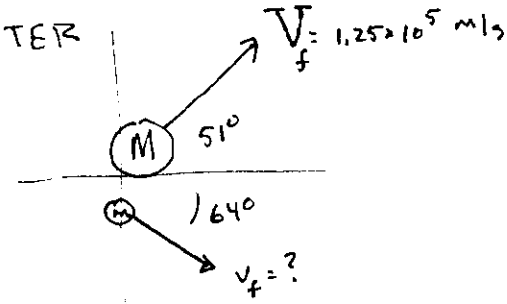

Total Init $\vec{P}$ = Total Final $\vec{P}$

Tot Init P_x = Tot Final P_x

$m v_0 = m v_f \cos 64° + M V_f \cos 51°$

$4 v_0 = 4(4.32 \times 10^5) \cos 64° + 16(1.25 \times 10^5) \cos 51°$

$v_0 = 5.04 \times 10^5$ m/s

Tot Init P_y = Tot Final P_y

$0 = M V_f \sin 51° - m v_f \sin 64°$

$0 = 16(1.25 \times 10^5) \sin 51° - 4 v_f \sin 64°$

$v_f = 4.32 \times 10^5$ m/s