(1) A worker in a railroad car that is initially at rest moves 50 boxes, with masses of 20 kg each, from the front to the rear of a 12-m-long, unattacked railroad car on a horizontal track. During this activity, the car moves 0.2 m forward. If the wheel bearings are frictionless, what is the mass of the car?

10%

(2) The chain of a bicycle pulls a force $F = 24\ N$ on the sprocket wheel of radius $R_1 = 5\ cm$. If the wheel runs without sliding. Find (a) the acceleration of the wheel, (b) the force the ground pushing the wheel. Assume that $R_2 = 30\ cm$ and the entire mass of the wheel is 2 kg along the rim.

18%
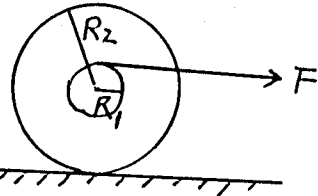
(3) A transverse wave on a string is given, in SI unit, by
$$y(x,t) = 0.02\ cos(30\pi t - 5\pi x)$$
(a) In what direction and speed does the wave travel?
(b) What are the frequency, wavelength and amplitude of the wave?
(c) What is the velocity of a particle of the string?

18%

(4) An infinitely long, nonconducting cylinder with a radius R has a charge density depending on the distance r from the axis as $\rho(r) = \rho_0 (r/R)^2$. Find the electric field as a function of r.

18%

(5) Find the magnetic field on the axis of a circular loop carrying a current I.

18%

(6) (a) Suppose 1 mole of helium is taken around the cycle processes $abdea$ shown in the figure. Assume that $P_0 = 2 \times 10^4\ N/m^2$ and $V_0 = 0.1\ m^3$. Determine the heat flows during the processes ab, bd, be, and ea.
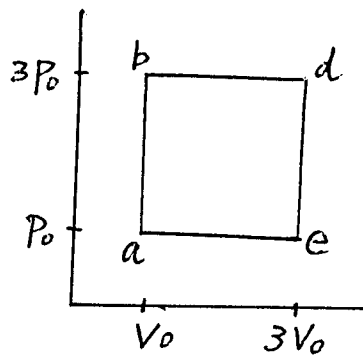
(b) If this is a cycle for an engine, what is its efficiency?

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